SIGNALIZATION STUDY
for
BILLINGS, MONTANA

PART B - ANALYSIS

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BILLINGS, MONTANA

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Prepared for

MONTANA HIGHWAY COMMISSION
PLANNING SURVEY SECTION

and

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CITY-COUNTY PLANNING BOARD

In Cooperation With

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By

CLARK, COLEMAN & RUPEIKS, INC.

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The opinions, findings and conclusions expressed in this publication are those of the authors and not necessarily those of the Bureau of Public Roads.

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INTRODUCTION

The 1962 Federal Highway Act requires that transportation planning in metropolitan areas be carried out on a continuing basis. Thus, in the fall of 1966 the Montana Highway Commission began work on updating the previously prepared transportation plan in Billings. The Commission felt that the long-range plan should also contain recommendations on improvements that can be quickly implemented resulting in immediate benefits to the traveling public. The study of traffic signal control was then made part of the transportation planning program. The firm of Clark, Coleman and Rupeiks, Inc. was retained to carry out the technical phases of the update and prepare a transportation plan.

The objective of the traffic signal study is to identify and outline the improvements necessary to provide an improved level of traffic service, provide greater safety and reduce system maintenance costs. Any system improvements, of course, will conform to the national standards of uniformity.

The report has been structured in three distinct sections. One section describes the existing signal system and inventories the equipment. The national standards are discussed and the current signal installations are evaluated in light of these standards. The second section describes the currently needed improvements in the signal system. It recommends standardization of design, equipment and maintenance procedures. The type of control system most suited for the Central Business District and on radial arterials will be discussed. In section three the complex intersections are given individual treatment.

The fast rate of change in traffic safety standards, acceptance of more stringent traffic flow regulations and improvement in electronic technology

make long-range planning for signal improvement somewhat ineffective. Review of operational problems must be made on a continuous basis as the City develops and requires the services of a full-time Traffic Engineer to study the changing traffic needs, as the dynamics of the traffic system are influenced by new parking facilities, industrial and commercial development. Recommendations in this report are based upon the current operational problems together with known trends of development for the immediate future traffic needs.

CHAPTER I

PRESENT SYSTEM

Improvement of traffic signal systems in Billings and most other urban areas is a continuing process. Some installations and equipment are new and effective, while others are obsolete and hazardous to proper traffic safety. Before any recommendations can be made, the effectiveness of the current systems and equipment must be evaluated. The evaluation of each installation was made on the basis of nationally and locally accepted standards.

INVENTORY

The signal study in Billings may well begin with an inventory of equipment and installations. Each intersection was field surveyed and photographs were taken of each intersection and of each controller. This inventory is included as a separate document to be used as a working tool for operational planning and records.

Equipment

The equipment inventory includes the mounting type, controller type, signal head placement, signal timing and other pertinent information.

Analysis of the 59 signalized intersections indicates that the most predominant type of signal head mounting is of the diagonal span wire type, found at 38 intersections. Four intersections have a "box" type span wire signal head mounting. Fourteen signalized intersections have the mast arm. Table A lists the number of intersections by mounting type.

A summary of Controller Type by intersections is shown in Table B. Fifty-one of the 59 intersections investigated are controlled by fixed time traffic

TABLE A

INTERSECTION CLASSIFICATION BY MOUNTING TYPE

Mounting Type	Number of Intersections
Diagonal Span Wire	38
Box Span Wire	4
Mast Arm	14
Combination	3
TOTAL	59

TABLE B

INTERSECTION CLASSIFICATION BY CONTROLLER TYPE

GS-4	GS-5	KS-1	LS-1	PCN-100	Econ F	Semi-Actuated
36	1	2	3	15	51	54
40	4	7	8	17	53	57
41	5	9	22	18		58
42	10	11	31	19		59
43	12	23	50	20		60
47	13	37		21		
55	14	44		24		
	16	46		25		
	28	48		26		
	29	49		27		
	30					
	32					
	33					
	34					
	35					
	39					
7	16	10	5	10	2	5

49 Crouse-Hinds

2 Econolite

4 Automatic signal

55*

*Does not include four flashing beacons

signal controllers. Five of the fixed time controllers are three-dial, expansible type, capable of coordination into a flexible progressive system. Forty-eight of the 55 intersections are controlled by Crouse-Hinds fixed time equipment. Four intersections installed by the Montana Highway Department on Highway U. S. 10 in northeastern Billings and the intersection at Grand Avenue and 15th Street West are of actuated type. These four are solid state semi-actuated controls.

System

For purposes of this study, a signal system shall be defined as two or more adjacent intersections where progressive traffic movement is obtained. There are five signal systems presently in operation in the Study Area. These are: the Central system, the First Avenue system, Division system, 6th Street West system and U.S. Highway 10 and 12 system.

The Central system includes those signals from Montana Avenue through Sixth Avenue North including all streets from North 27th Street to North 32nd Street, plus two intersections on First Avenue North at North 25th Street and North 26th Street for a total of 27 intersections. The system operates as a double alternate with the intersections on Montana Avenue at North 27th, 28th and 29th Streets and the intersections on Fourth Avenue North and Sixth Avenue North at North 27th, 28th, 29th and 30th Streets all coordinated manually to operate with the CBD interconnected system. Interconnect cable was installed during the recent widening of North 27th Street which will tie the intersections on North 27th Street at Fourth Avenue North and Sixth Avenue North into the CBD interconnected system.

The First Avenue South system is cable interconnected and consists of the three intersections on First Avenue South at South 27th, 28th and 29th Streets. This system operates simultaneously.

The Division Street system consists of the intersections of Division Street with Montana Avenue, Broadwater Avenue and First Avenue North. All intersections are controlled by a single master unit located just south of Broadwater Avenue. Three cycle lengths are available: 60 second, 70 second and 80 second, with the intersection of Montana and Division operating with two phases and the intersection of Division, Broadwater and First Avenue North requiring three phase operation. The progression is simultaneous.

The Sixth Street system provides progression between the two intersections of Sixth Street West at Central and State Avenues which are separated by approximately 700 feet. The signal at State Street operates two phase with leading green left turn arrows north-south and east-west. The signal at Central Avenue operates three phase. The present progression is directional.

The U.S. Highway 10 and 12 system consists of four interconnected semi-actuated traffic controls at the intersections of Main Street (U.S. Highway 10 and 12) at Sixth Avenue North, Montana Highway 318, Lake Elmo Road and Milton Road. Uninterrupted flow is maintained on Main Street unless a vehicle arrives on one of the side streets or a pedestrian activates the controller to cross Main Street.

NATIONAL STANDARDS

The national minimum standards for Traffic Signals are provided for in the "Manual of Uniform Traffic Control Devices for Streets and Highways," published by the U. S. Department of Commerce, Bureau of Public Roads, 1961. This manual is currently under revision by the "National Joint Committee on Uniform Traffic Control Devices." Review of drafts of the proposed revisions indicate that although many refinements will be forthcoming, the basic concept remains unchanged from the 1961 manual.

Because of the increasing range of traffic circulation in an affluent society, the importance of national standardization of those features of traffic

signals that affect public participation in traffic movement must not be overlooked. Location of signal faces and sequence of operations are basic requirements. Signals must be placed where the driver cannot miss seeing them.

The basic requirements are listed below:

A. Number of Signal Faces

There shall be a minimum of two vehicular signal faces visible to traffic on each approach to a signalized intersection.

B. Location of Signal Faces

The location of signal faces for each direction of approaching traffic shall be as follows:

1. Where all signal faces are post- or pedestal-mounted there shall be at least two on the far side of the intersection.
2. Where there is only one post- or pedestal-mounted signal face, it shall be on the far side, and there shall also be a mast-arm or span-wire mounted signal face for that approach.
3. Where visibility or other conditions require more than one span-wire or mast-arm signal, at least one of the overhead signal faces shall be in line with the approach it controls. Signal faces shall be located so as to give drivers and pedestrians a clear and unmistakable indication of the right-of-way assignment from their normal positions on the approaches and as they enter or pass through the intersection area.

The requirement of "two properly located signal faces per direction" is of major importance in assuring that indications are always visible to the motorist. Many times the presence of a truck in the traffic stream can block the signal vision of subsequent motorists; however, the truck will rarely block the vision of two properly located signal faces. The double indication is also protection against possible lamp burn out. Seldom would both indications burn out simultaneously. These factors are

extremely important in this age of increasing public liability. If placement and number of indications are substandard, the City could be subject to defending its reasons for maintaining the system below a recognized minimum level of safety.

DEFICIENCIES

The inventory of signalized intersections indicated that 38 of the 59 intersections were below national standards. The designs to upgrade existing locations are beyond the scope of this study, but would require major modification of the 38 substandard locations. One hundred and thirty-six additional signal faces are required, a 45 percent increase over the present number of 303.

The magnitude of the deficiency of traffic signal faces indicates that standardization of design should be undertaken both in an effort to maintain consistency within the City and also in reducing the cost of installations. Table C lists the deficiencies in mounting and in the number of vehicular and pedestrian signal heads.

As a general policy, pedestrian indications should be installed with all traffic actuated equipment where pedestrians are present. If this is not done, the equipment has to be so timed to lose much of its flexibility. In addition to actuated signals, it is also common practice to install pedestrian signals at signalized intersections used for school crossings where children will be inclined to start to cross on the green with inadequate time to complete the crossing prior to the signal changing.

Pedestrian signal indications are advisable at uncommonly wide intersections where a pedestrian leaving the curb during the latter part of the green is likely to be trapped in the traveled roadway when the light changes. The use of pedestrian signal indications in central business areas is recommended as a means of controlling pedestrian traffic so that stragglers will not continue to cross the street during the red indication. This is most important

TABLE C

COMPARISON OF EXISTING SIGNAL INSTALLATIONS WITH NATIONAL STANDARDS
Manual on Uniform Traffic Control Devices, 1961

Intersection Number	Intersection Location	Type of Mounting	Meets Uniform Standards Yes	Meets Uniform Standards No	Number of Signal Faces Existing	Number of Signal Faces Min. Req.	Number of Signal Faces Deficiency	Remarks
1	27th St. N. & 9th Ave. N.	D.W.[1]		X	4V[4]	8V	4V	4 M.A. Luminaires
2	6th Ave. N. & N. 27th St.	D.W.		X	4V	8V8P	4V8P	4 M.A. Luminaires Heads not centered
3	Division at Grand & 6th Ave. N.	B.W.[2]		X	6V10P[5]	10V10P	4V8P	8 Pedestrian signals are 9" round non-std, 3Ø
4	N. 29th St. & 6th Ave. N.	D.W.		X	4V	8V	4V	B.W. Lane Use Signs, N.S.
5	6th Ave. N. & N. 28th St.	D.W.		X	4V	8V	4V	B.W. Lane Use Signs, N.S.
6	Ave. C and N. 32nd St.	W.		X	3V	3V		Replace blazing beacon with flashing amber beacon
7	6th Ave. N. & N. 19th St.	D.W.		X	4V	8V	4V	
8	4th Ave. N. & Division St.	MA.[3]	X		8V8P	8V8P		No luminaires M.A. Lane use signs
9	4th Ave. N. & N. 32nd St.	D.W.		X	4V	8V	4V	4 M.A. Luminaires
10	4th Ave. N. & N. 30th St.	D.W.		X	4V	8V	4V	
11	4th Ave. N. & N. 29th St.	D.W.		X	4V8P	8V8P	4V B.W.	4 M.A. Luminaires Lane Use Sign N. S.
12	4th Ave. N. & N. 28th St.	D.W.		X	4V8P	8V8P	4V B.W.	New luminaires Lane use signs N.S.
13	4th Ave. N. & N. 27th St.	D.W.		X	4V	8V8P	4v8P	New luminaires
14	3rd Ave. N. & N. 30th St.	D.W.		X	4V	8V8P	4V8P	New luminaires

Intersection Number	Intersection Location	Type of Mounting	Meets Uniform Standards Yes	Meets Uniform Standards No	Number of Signal Faces Existing	Number of Signal Faces Min. Req.	Number of Signal Faces Deficiency	Remarks
15	3rd Ave. N. & N. 29th St.	M.A.	X		8V8P	8V8P		Luminaire set on M.A. signal pole
16	3rd Ave. N. & N. 28th St.	M.A.		X	4V8P	8V8P	4V	New luminaires B.W. Lane use signs N.S.E.W.
17	3rd Ave. N. & N. 27th St.	D.W.		X	4V8P	8V8P	4V	New luminaires B.W. Lane use signs E.W.
18	2nd Ave. N. & N. 30th St.	D.W.		X	4V	8V	4V	New luminaires
19	2nd Ave. N. & N. 29th St.	M.A.	X		8V8P	8V8P		New luminaires B.W. Lane use sign N.S.E.W.
20	2nd Ave. N. & N. 28th St.	M.A.	X		8V8P	8V8P		New luminaires B.W. Lane use sign N.S.E.W.
21	2nd Ave. N. & N. 27th St.	M.A.		X	4V8P	8V8P	4V	New luminaires B.W. Lane use signs E.W.
22 31 50	1st Ave. N. & Division St. Montana Ave. & Division St. Broadwater Ave. & Division St.	D.W.		X	9V	14V8P	5V8P	Complex geometrics
23	1st Ave. N. & N. 32nd St.	D.W.		X	4V	8V	4V	New luminaires
24	1st Ave. N. & N. 30th St.	M.A.	X		8V	8V		New luminaires
25	1st Ave. N. & N. 29th St.	M.A.	X		8V8P	8V8P		New luminaires B.W. Lane use signs N.S.
26	1st Ave. N. & N. 28th St.	M.A.	X		8V8P	8V8P		New luminaires B.W. Lane use signs N.S.
27	1st Ave. N. & N. 27th St.	M.A.		X	4V8P	8V8P	4V	New luminaires
28	1st Ave. N. & N. 26th St.	D.W.		X	4V8P	8V8P	4V	New luminaires
29	1st Ave. N. & N. 25th St.	D.W.		X	4V	8V	4V	New luminaires
30	1st Ave. N. & N. 13th St.	D.W. & M.A.		X	5V	8V	3V	NB-RB Arrow

Intersection Number	Intersection Location	Type of Mounting	Meets Uniform Standards Yes	Meets Uniform Standards No	Number of Signal Faces Existing	Number of Signal Faces Min. Req.	Number of Signal Faces Deficiency	Remarks
31	Montana Ave. & Division St.							See #22
32	Montana Ave. & N. 29th St.	D.W.		X	4V	8V	4V	New luminaires B.W. Lane use signs N.S.E.W.
33	Montana Ave. & N. 28th St.	D.W.		X	4V	8V	4V	New luminaires B.W. Lane use signs N.S.E.W.
34	Montana Ave. & N. 27th St.	D.W.		X	4V	8V	4V	New luminaires B.W. Lane use signs E.W.
35	1st Ave. S. & S. 29th St.	D.W.		X	4V	8V	4V	New luminaires B.W. Lane use signs N.S.
36	1st Ave. S. & S. 28th St.	D.W.		X	4V	8V	4V	New luminaires B.W. Lane use signs N.S.
37	1st Ave. S. & S. 27th St.	D.W.		X	4V	8V	4V	New luminaires B.W. Lane use signs N.S.
38	Rimrock Rd. & 13th St. W.	D.W.	X		2V	2V		Amber flasher
39	Poly Drive & Virginia Lane	M.A. & D.W.		X	6V	10V	4V	Complex geometrics
40	Grand Ave. & 17th St. W.	D.W.	X		8V	8V		Signal heads too close together
41	Grand Ave. & 16th St. W.	D.W.	X	X	6V	6V8P	8P	Signal heads too close together B.W. Lane use signs S. leg
42	Grand Ave. & 13th St. W.	D.W.	X	X	8V	8V8P	8P	Slight jog in intersection, N.S.
43	Grand Ave. & 8th St. W.	D.W.	X	X	8V	8V8P	8P	Signal heads too close together
44	Grand Ave. & Virginia Lane	D.W.		X	4V	8V8P	4V8P	Jog N.S.
45	Lewis Ave. & 24th St. W.	D.W.	X		4V	4V		Red-amber flasher
46	Lewis Ave. & 5th St. W.	D.W.		X	4V	8V	4V	
47	Broadwater Ave. & 16th St. W.	D.W.		X	4V	8V	4V	

Intersection Number	Intersection Location	Type of Mounting	Meets Uniform Standards Yes	Meets Uniform Standards No	Number of Signal Faces Existing	Number of Signal Faces Min. Req.	Deficiency	Remarks
48	Broadwater Ave. & 8th St. W.	D.W.		X	4V	8V	4V	
49	Broadwater Ave. & 5th St. W.	B.W.	X		8V8P	8V8P		
50	Broadwater Ave. & Division St.							See #22
51	Central Ave. & 6th St. W.	B.W.	X		8V4P	8V4P		Flag one way
52				Removed				
53	Minnesota Ave. & 6th St. W.	B.W.	X		8V4P	8V4P		
54	Grand Ave. & 15th St. W.	M.A.	X		8V8P	8V8P		B.W. Lane use S. leg
55	6th Ave. N. & N. 30th St.	D.W.		X	4V	8V	4V	
56	U. S. 10-12 & U. S. 87E	M.A.	X		1V	1V		Flashing beacon
57	Main St. & 6th Ave. N.	M.A.	X		6V	8V		
58	Main St. & Montana Hwy. 318	M.A.	X		8V	6V		
59	Main St. & Lake Elmo Road	M.A. &B.W.	X		9V	8V		
60	Main St. & Milton Road	M.A.	X		6V4P	6V		

Remarks:

[1] D.W. - Diagonal Wire
[2] B.W. - Box Wire
[3] M.A. - Mast Arm
[4] 4V - Four Vehicular Signal Heads
[5] 10P - Ten Pedestrian Signal Heads

in an area where many distractions and conflicts confront the motorist. Police enforcement is generally needed to assist in educating the pedestrians to ensure that they understand the meaning of the signals.

Pedestrian signal timing and indications are the least understood of all traffic control devices as they appear unreasonable to many pedestrians. However, without such controls the straggling pedestrian presents an accident potential and reduces the capacity of the critical urban intersections. Warrants for Pedestrian Signals are given under Section 3F-2 of the Manual of Uniform Traffic Control Devices as follows:

> Pedestrian signals shall be installed in conjunction with vehicular traffic signals already meeting one or more of the minimum warrants previously set forth for pre-timed or traffic-actuated signals, under any of the following conditions:
>
> 1. When a traffic signal is installed under the pedestrian volume warrant.
> 2. When pedestrians and vehicles move during the same phase and properly adjusted pedestrian clearance intervals are needed to minimize vehicle-pedestrian conflicts.
> 3. When an exclusive phase is provided or made available for pedestrian movement in one or more directions, all vehicles being stopped.
> 4. When heavy vehicular turning movements require a semi-exclusive pedestrian phase for the protection and convenience of the pedestrian.
> 5. When pedestrian movement on one side of an intersection is permissible while through vehicular traffic is stopped to protect a vehicular turning movement on the other side of the intersection.
> 6. When an intersection is so large and complicated or a street so wide that vehicular signals would not adequately serve pedestrians.

7. When the minimum green intervals for vehicles at intersections with traffic-actuated controls is less than the minimum crossing time for pedestrians and equipment is provided which extends the vehicular green time upon pedestrian actuation.
8. When multi-phase or split-phase timing would tend to confuse pedestrians guided only by vehicle signal indications.
9. When pedestrians cross only part of the street, to or from an island, during a particular phase.

A planned program is needed to upgrade the pedestrian control and should be conducted in regard to a priority of need.

Of the 142 pedestrian signals, 134 meet present standards. Twenty-four of the 55 signalized intersections were considered to have sufficient pedestrian traffic to require more detailed evaluation for the pedestrian warrants listed under Section 3F-2 of the "Manual on Uniform Traffic Control Devices for Streets and Highways." Seven variables were given consideration in determining priorities for pedestrian signal indications. These were:

1. Pedestrian volume
2. Vehicle volume
3. Vehicle speeds
4. Street width
5. Visibility of existing signal heads
6. Complexity of intersection
7. Adjacent land use

The twenty-four intersections are listed in Table D by order or priority as determined by this evaluation.

The intersections which have the top five priorities are listed in Table D as deficient. There are eight intersections in this group for a deficiency of 64 pedestrian signal indications. This represents a 46 percent increase over the present system.

TABLE D

PEDESTRIAN SIGNAL INDICATIONS PRIORITIES ON 24 INTERSECTIONS

Intersection	Priority
1st Avenue N. - Division Street	1
Grand Avenue - 8th Street W.	2
Grand Avenue - Virginia Lane	3
N. 27th Street - 4th Avenue N.	4
N. 27th Street - 6th Avenue N.	4
Grand Avenue - 13th Street W.	5
Grand Avenue - 16th Street W.	5
N. 27th Street - 1st Avenue S.	5
N. 28th Street - 6th Avenue N.	6
N. 29th Street - 6th Avenue N.	6
N. 30th Street - 4th Avenue N.	6
S. 29th Street - 1st Avenue S.	6
Grand Avenue - 17th Street W.	7
S. 28th Street - 1st Avenue S.	7
N. 27th Street - Montana Avenue	7
N. 28th Street - Montana Avenue	7
N. 29th Street - Montana Avenue	7
N. 30th Street - 3rd Avenue North	7
N. 27th Street - 9th Avenue N.	8
N. 30th Street - 6th Avenue N.	8
Broadwater Avenue - 16th Street W.	9
N. 25th Street - 1st Avenue N.	9
N. 30th Street - 2nd Avenue N.	9
N. 32nd Street - 4th Avenue N.	9

CHAPTER II

PRESENTLY NEEDED IMPROVEMENTS

Certain needed improvements in the signal system should be carried out immediately to benefit the traveling public. Improvements in the signal system, as well as in individual locations, will be discussed.

STANDARDS

The orderly and efficient installation of a city-wide traffic signal system calls for basic guidelines to be followed. The amount of engineering required for a signal installation can be reduced to a bare minimum if "standard plans" and "General Specifications" for Traffic Signals and Highway Lighting Systems are adopted. Initial design costs are reduced, as are construction costs when contractors and construction crews are provided with a uniform type of installation. The uniformity produced also assures both motorist and pedestrian of the safest possible system.

Design and Equipment

The specific type of signal mounting to become the standard should be decided at the time of specification adoption. The three basic choices approved by the "Manual on Uniform Traffic Control Devices" are "post mounted," "span wire" and "mast arm." The "post mounted" signals are placed on the far side of the intersection. View of this type can be blocked by large vehicles. The "span wire" signals require overhead wires that may cause clearance problems for oversize loads. The signal heads are also less stable in high winds. The "mast arm" installation provides both a high indication for unobscured vision and a low indication for easy vision from the stop line. All signal heads may be rigidly fixed and provided with back plates to shield sun glare, advertising light, etc. The mast arm type is recommended for adoption as a standard and incorporated wherever possible into combination

poles with street lighting. Standard equipment should be selected and the contracts for modernization written to exclude brands for which additional spare parts must be purchased.

In summary, standard plans and specifications are necessary to establish high standards of quality and performance that will guide contractors and suppliers doing business with the City. Figures 1, 2 and 3 show the recommended standard signal installation.

Records and Maintenance

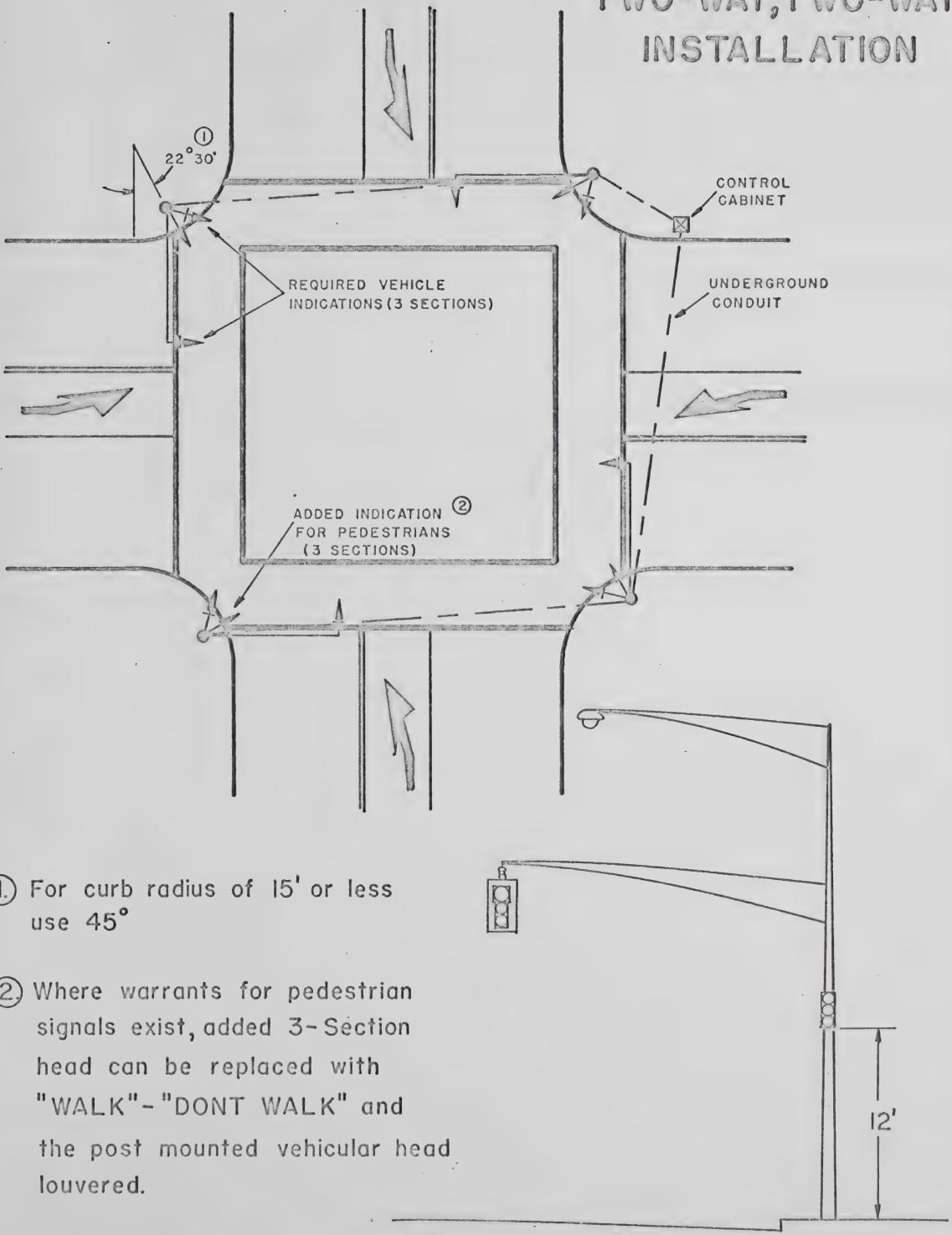
Adequate records and maintenance systems are required to assure efficient continued functioning of the signal system, to provide data for equipment performance evaluation and to protect the City from claims of negligence. Office records should consist of a file of construction plans for all signalized intersections and any modifications, current signal timing data including equipment type, phasing, interval timing, offset, date of change and authorization of the timing; and previous timing data, including installation and removal dates. This last item is important for court testimony in accident cases. Figure 4 indicates a good type of record file card.

Shop records should include current plans and timing records, and records on all phases of cleaning, maintaining, painting and repairing. These records tell of the efficiency of the equipment and could also be needed for court testimony.

Records in the control cabinet at the intersection may be kept in waterproof containers and should consist of current signal timing and the wiring plan if unusual phasing or connections are required.

Preventive maintenance is a requirement of a traffic control system, and some manufacturers recommend at least a yearly schedule. Properly designed plug in or jack mounted equipment can be replaced by components during routine maintenance or in the event that emergency repair is necessary.

STANDARD TWO-WAY, TWO-WAY INSTALLATION

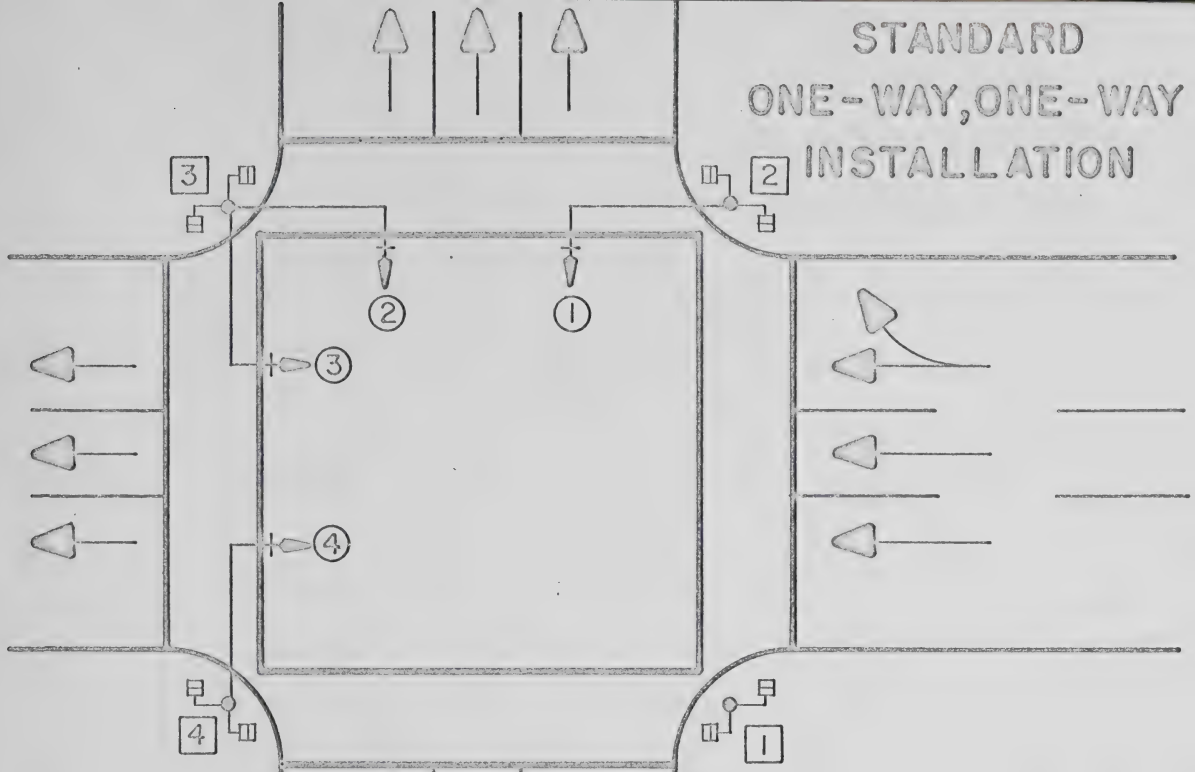


① For curb radius of 15' or less use 45°

② Where warrants for pedestrian signals exist, added 3-Section head can be replaced with "WALK"-"DONT WALK" and the post mounted vehicular head louvered.

FIG. 1

STANDARD ONE-WAY, ONE-WAY INSTALLATION



HEADS

1 & 4 (R) (A) (G) 2 & 3 (R) (A) (G)

POLES

1 - TYPE I (10')

2,3,4 - TYPE III or TYPE II

(Where existing luminaire is to remain.)

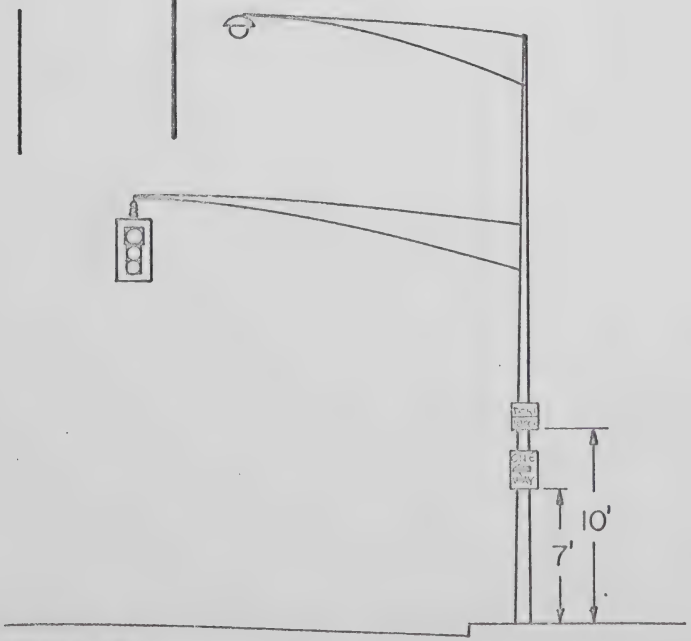
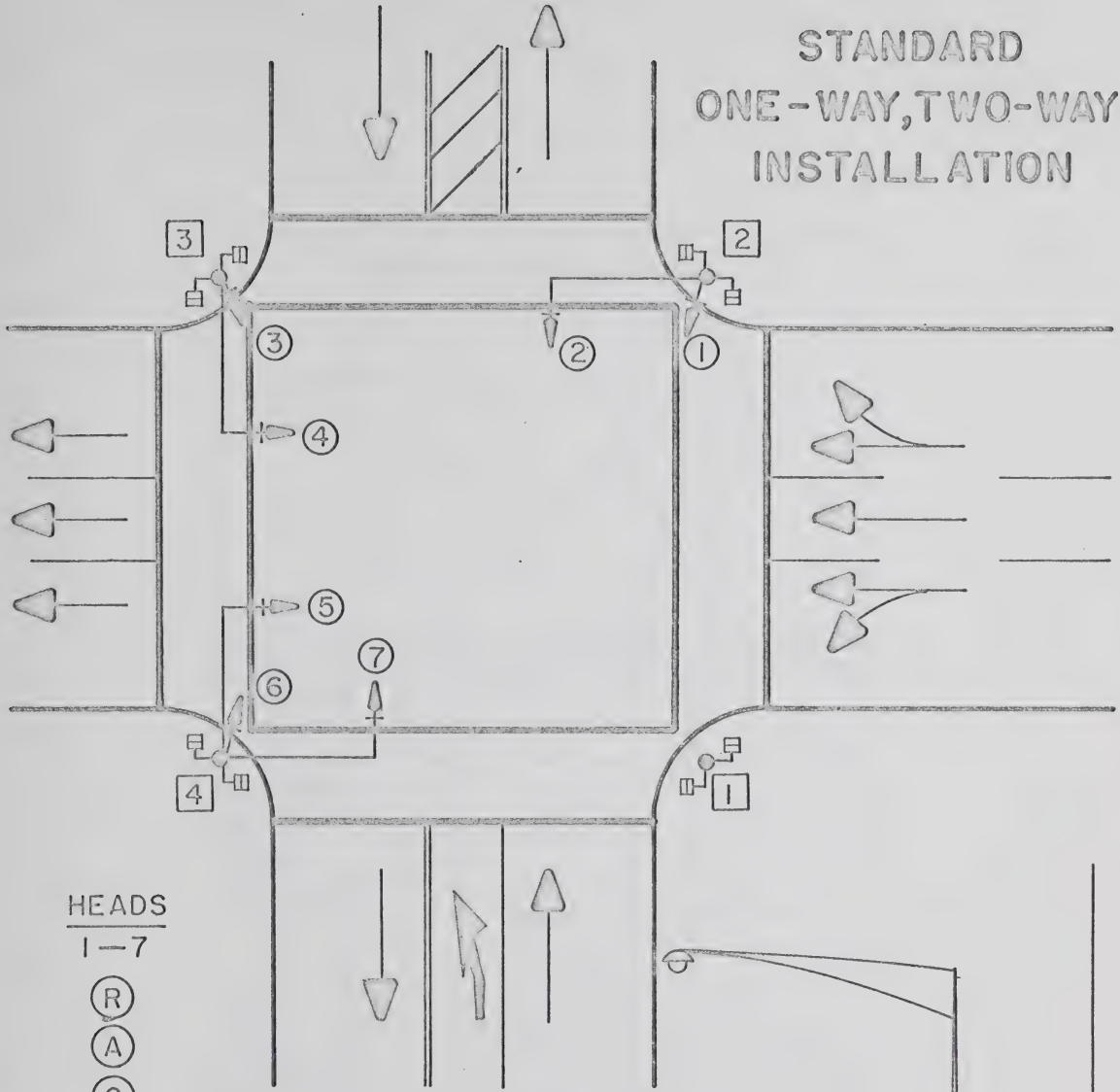


FIG. 2

STANDARD ONE-WAY, TWO-WAY INSTALLATION



HEADS

1 – 7

R

A

G

POLES

1 – TYPE I (10')

2,3,4 – TYPE III

or

TYPE II

(Where existing luminaire is to remain.)

FIG. 3

SIGNAL TIMING CARD

CITY OF BILLINGS, MONTANA

Location_____ & _____

Date_____ By_____

Dial 1____Sec 2____Sec 3____Sec

Phase	%	Sec	Pins	%	Sec	Pins	%	Sec	Pins
E-W									
Green									
Ped Walk									
Ped Clear									
Amber									
All Red									
N-S									
Green									
Ped Walk									
Ped Clear									
Amber									
All Red									

FIG. 4a

SIGNAL TIMING CARD

CITY OF BILLINGS, MONTANA

Location _____ & _____

Date _____ By _____

	PHASE A	PHASE B	PHASE C
Initial			
Vehicle			
Maximum			
Amber			
All Red			
Recall			
On			
Off			
Minor Movement			
Initial			
Vehicle			
Maximum			
Clear			

Remarks _____

FIG. 4b

Signal lamps should be replaced on a systematic basis to avoid repeated trips to an intersection. Maintenance records should be able to yield the life expectancy of the various lamps.

Signal lenses should be cleaned at least twice a year and whenever lamps are replaced, according to the manufacturer's instructions regarding cleaning. The diffusion of light caused by dust on the lens, lamp and reflector may appreciably reduce both light output and overall efficiency.

Painted signal heads, brackets, poles, posts, control pedestals, cabinets and conduits above ground should be repainted every two years or as often as necessary to maintain good appearance and prevent corrosion of the equipment. In general, standard colors should be chosen. Where heat is a problem, cabinets should be painted white or silver. Signal poles are an important part of the control unit and to assure contrast, highway yellow is recommended. Poles located in areas exposed to traffic should also be banded with a reflectorized sheeting.

The City of Billings has kept maintenance records on the signal system since 1962. These records, which are maintained by the city electrician, list the controller type, location, and any services or repairs. There is also an established service and repair program. All controllers are brought in for service or preventive maintenance a minimum of once a year. Signal lamps are replaced annually and at the time the lenses and reflectors are cleaned. Signal heads, poles and cabinets are painted a standard color as often as necessary and are maintained to present a good appearance.

The currently initiated system of keeping a maintenance file card for each signalized intersection should be continued with sufficient information to describe all malfunctions corrected, or maintenance performed and to include date performed. Signal lamp burn out replacements and damaged signals repaired should also be recorded here so that a check of a single file

can be made to provide information regarding law suits against the City claiming signal malfunction or to determine any trends in malfunctions. Records of any and all signal timing changes should be kept both for legal and engineering analysis purposes. In general, the maintenance of signal equipment in the field has been excellent.

SYSTEM PROPOSALS

In general, all traffic signals within one-quarter of a mile of each other and controlling the same traffic should be coordinated. Considerable success has been achieved in coordinating signals with up to one-half mile spacing under relatively free flowing traffic conditions. The efficiency of any system is limited by the proximity of adjacent signals, street width, complicated intersections, desired travel speed, requirements for two directional operation, pedestrian conflicts, parking and many other factors.

Analysis indicates that all but three of the City's signals fall within one-half mile of the next adjacent signal. Expansion will probably bring these three within this limit in the near future.

It is proposed that the City plan for a total system wherein the time relationships between any two signals in the City may be determined. Traffic necessity, financial capability and availability of construction personnel will determine the staging and completion of the total system.

Basically there will be a need for a Central system to control the Central Business District, a radial system to control the western area, and isolated systems to control minor groups of signals.

Central Business District

The Central system should control all signals to be coordinated in the old street system, i.e., those streets which run parallel and perpendicular to the railroad tracks. The new "Central system" would encompass the previously described Central and the First Avenue systems.

The following parameters are common to the central area:

1. Standard street spacing of 380' per block
2. Speed limit 25 m.p.h. (with minor exceptions)
3. Street widths in the vicinity of 50 feet
4. Relatively high turning movements and pedestrian conflicts
5. Curb parking exists
6. Two-way streets

Speeds of 20 m.p.h. are desirable and acceptable in a Central Business District. Under ideal conditions, with the 380 foot street spacing, traffic signals would turn green 13 seconds after the preceding signal for perfect progression and a motorist could drive the length of the signal system at 20 m.p.h. In actual practice, however, speed and delay of the driver is normally not governed by the signal operation but rather by the amount of interference encountered. On the four lane streets, the driver has the option of changing to the center lane to bypass parking maneuvers, but the center lane may be blocked by left turning movements which must wait for all opposing traffic to clear with the exception of First Avenue North where left turns are prohibited. The use of exclusive protected turning movements and exclusive protected pedestrian intervals are effective only where through traffic movements are light and can be penalized for the benefit of other traffic. A Central Area signal system must take all these variables into account and make adjustments for changing conditions.

In general, there are only four types of progressive signal systems. Each type, briefly described below, has specific advantages and disadvantages:

1. Simultaneous: All signals along a given street display green at approximately the same time.
2. Alternate: All signals along a given street display alternate indications.
3. Simple progressive: All signals along a given street display the green indication at a pre-determined time interval to allow a designated speed.

4. Flexible progressive: A system which changes from one simple progressive system to another with changing traffic demand.

The choice between alternatives is an administrative decision which will have to made by City government. The first fact which must be recogized is that closely spaced signalized intersections cannot be timed for perfect progression in both directions.

The first policy decision is whether the Central Business District will remain with all two-way streets. Perfect progression can be obtained with a one-way grid system with continuous speeds in the range of 20 mph. Nearly all major cities have been forced to adopt one-way systems both to avoid congestion and to maintain some on-street parking. The one-way system is undeniably the safest and most efficient use of Central Business District streets in moving traffic. Among the western cities using a one-way grid in the central city are Albuquerque, Phoenix, Tucson, San Diego, Los Angeles, San Francisco, Portland, Tacoma, Seattle, Spokane and Boise.

If a two-way system is to be retained, three basic choices of signal timing are one-way progression, double alternate and simultaneous.

The one-way progression system is timed for perfect progression with each alternate parallel street having progression only in a single direction, for example:

Streets progressed Eastbound	Streets progressed Westbound
4th Avenue North	6th Avenue North
2nd Avenue North	3rd Avenue North
Montana West	1st Avenue North
Streets progressed Northbound	**Streets progressed Southbound**
32nd Street	33rd Street
30th Street	31st Street
28th Street	29th Street
26th Street	27th Street

The advantages of this system are that if no conflict is encountered with parking or turning vehicles, a motorist traveling in the progressed direction can make every light in the system if he travels at the speed of progression. The traffic signals will effectively control speed as motorists exceeding the progression speed will arrive at the next intersection on the red indication.

Motorists traveling in the direction opposite progression will have to stop at each and every signal.

The double alternate system is basically the system now in use. Although this method allows for progression in both directions, the green time must be shared by both directions of travel. Some improvement can be made by transferring time from the cross street to the main street. This can be done advantageously only if the cross street is not already experiencing congestion.

As traffic volumes continue to increase, the double alternate system of progression will break down. Vehicles will queue up at the signals and turning movements will further restrict the movement of through vehicles.

A degree of speed control is provided by this method of operation during off peak time, but during peak traffic periods, satisfactory traffic flow cannot be achieved. Under all traffic conditions, the one-way street system has a distinct advantage.

Under the simultaneous system all signals along a given street turn green at essentially the same time; therefore, a longer signal cycle is normally required to allow the motorist to make more than two traffic signals without stopping. Longer cycles in many cases increase the delay to circulating traffic and unless enforcement is good, pedestrians may ignore the signals due to the long wait required. This type of system offers no speed control and its use should normally be limited to peak hour traffic conditions.

A one-way street system and signal timing will give the most efficient traffic movement. If the two-way system is to remain, the double alternate with parking restrictions during the hours of congestion would provide the next best solution, with possibly a simultaneous system during peak hours.

The two types of equipment available are "fixed time" controllers and "traffic actuated." Both types would be pre-programmed with one or more of the previously mentioned timing systems. The fixed time controller will

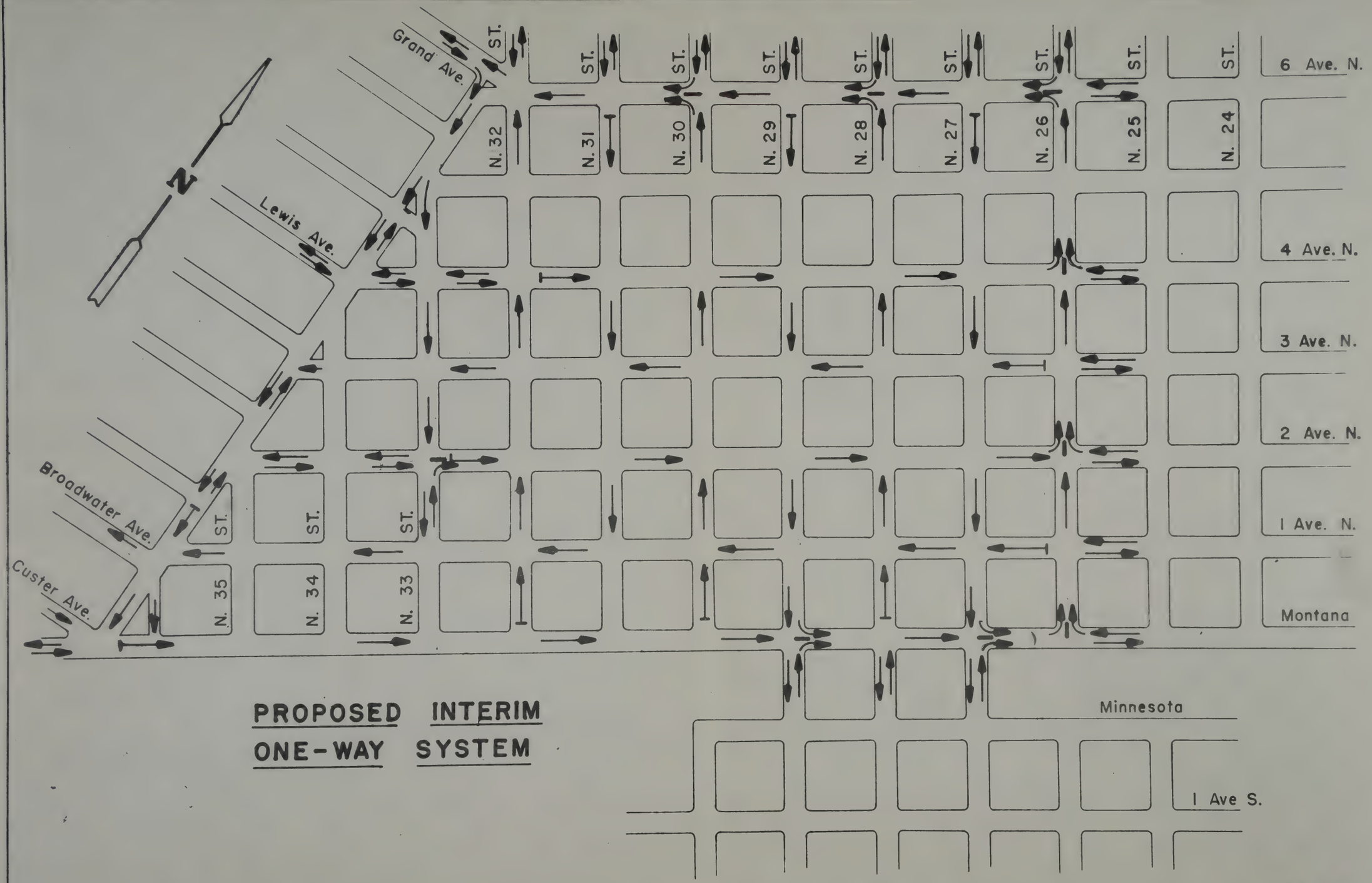
always give the same length of green time to each street every cycle until a change in system is called for. It may be desirable to have three or more systems programmed for use. These would normally be a morning system, an evening system and an average system. These systems may be automatically called for by a time clock or may be set manually. Up to nine systems can be programmed with standard expansible controllers.

The traffic actuated system operates in a similar manner, except that it may be "traffic adjusted," i.e., instead of a system being called for by a time clock, it may be automatically called for by the volume of traffic on the street. If traffic actuated intersection controllers are used, the amount of green indication for each approach to an intersection may vary from cycle to cycle depending upon the detection or non-detection of traffic. If no traffic is approaching on a minor street, the indication will remain green for the main street.

The advantages of the fixed time system are its consistency, lower cost and simpler maintenance. A failure in the system is easier to detect and initial installation is less involved.

The advantages of the traffic actuated system are that the system is responsive to traffic demands and, with proper timing, will not interrupt the major traffic flow any longer than necessary. The disadvantages are the higher costs associated with more sophisticated equipment and installation, the greater amount of design and location work required for traffic detection and the greater skill required to properly operate, adjust and maintain the system.

A 3 dial - 3 offset fixed time system is recommended to control the CBD system. Only two dials need be purchased initially. It is recommended that for immediate improvement in the system that the one-way street system shown in Figure 5 be installed. This system will allow the maximum efficiency using existing signal equipment. Some additional gain in efficiency could be expected when the intersection traffic controllers can be modernized to expansible equipment.



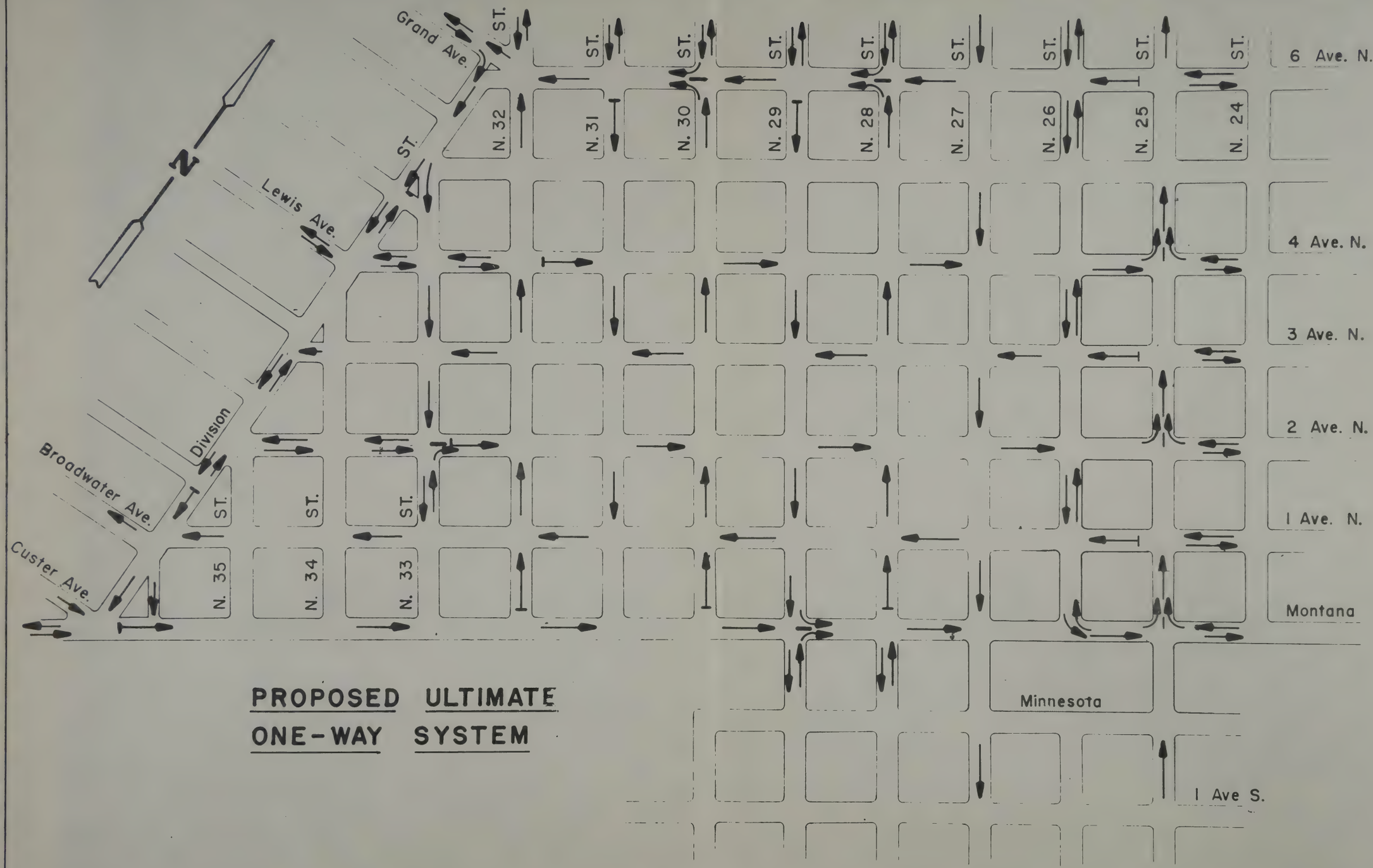
PROPOSED INTERIM ONE-WAY SYSTEM

FIG. 5

This one-way pattern is compatible with the 1990 arterial street system which proposed two one-way couplets: North 27th Street southbound - North 25th Street northbound, and Montana Avenue eastbound - First Avenue North westbound. This one-way system is necessary to accommodate the traffic volumes which will be generated by the Central Business District as demonstrated by the 1990 traffic assignments. The current building line precludes widening to accommodate the traffic volumes on a two-way street. Reversible lanes are not practical due to the nearly balanced traffic split. The interim one-way system shown in Figure 5 extends only from Sixth Avenue North through Montana Avenue and temporarily uses North 26th Street as the northbound connection rather than North 25th Street. When North 25th Street is developed as a one-way street and tied back into North 27th Street in the vicinity of the Canal (Poly Drive) then one-way operation on North 27th Street could be extended and the northbound one-way moved from North 26th Street to North 25th Street. North 26th Street would then become a two-way street. See Figure 6.

From a purely traffic operation and initial cost standpoint, the north-south pair should be North 27th Street northbound and North 28th Street (Broadway) southbound, as this connection leads directly into the area being served and the terminal connections are much easier to make. On the north, a connection could be made in the vicinity of Poly Drive; on the south, 28th already crosses the railroad. The other advantage of this couplet is that the alternate streets are opposite directions and traffic progression could be maintained. With the 27th-25th couplet, progression will have to be broken. The decision to locate the one-way couplet on 27th-25th was based upon the desire to keep any through traffic off North 28th Street (Broadway). The location of the Athletic Field precludes the use of 26th unless the northbound traffic were brought back to North 27th Street south of Ninth Avenue North.

The one-way grid has been expanded from these two one-way couplets to the adjacent streets in order to allow a reasonable traffic circulation and progression pattern. Parts of Fourth Avenue North and Division Street have



PROPOSED ULTIMATE ONE-WAY SYSTEM

FIG. 6

been left two-way to allow better circulation and access to Lewis Avenue and streets west of Division. Future traffic volumes may require extension of the one-way system, especially to the east where high traffic volumes are expected from the Highway 10 corridor.

Table E shows the typical offset pattern for a 50-second cycle which should be used to allow speeds in the range of 15 to 20 m.p.h. The progression speed is 21 m.p.h.; however, due to circulation traffic an operation speed of somewhat less can be expected.

Figure 7 shows the typical progression for the system. Only Sixth Avenue North and First Avenue South would differ from this.

If the one-way system is not installed, little improvement from the existing double alternate system can be expected as this system is the best for two-way operation. Figure 8 shows existing progression. Some adjustment could possibly be made by increasing the east-west signal split by ten percent at all intersections except those on North 27th Street (Figure 9), as the north-south traffic volume is somewhat higher at this location. As with any operational change, the proof of the efficiency must be checked on the street. It is possible that a change of fifteen percent which would reduce the north-south green time near the minimum pedestrian crossing time would be feasible.

Figure 10 shows the existing condition and channelization of the Central Business District. The critical intersections are in the heart of the business district where parking is at a premium. The only way to substantially increase the efficiency of the two-way system would be to remove parking, which would entail its relocation to off-street areas if the economic health of the Central Area is to be assured.

Interconnection

Interconnection of the central system can be done by cable, leased telephone circuit or radio control. Wherever possible, underground conduit

TABLE E

SIGNAL OFFSETS FOR PROPOSED ONE-WAY SYSTEM

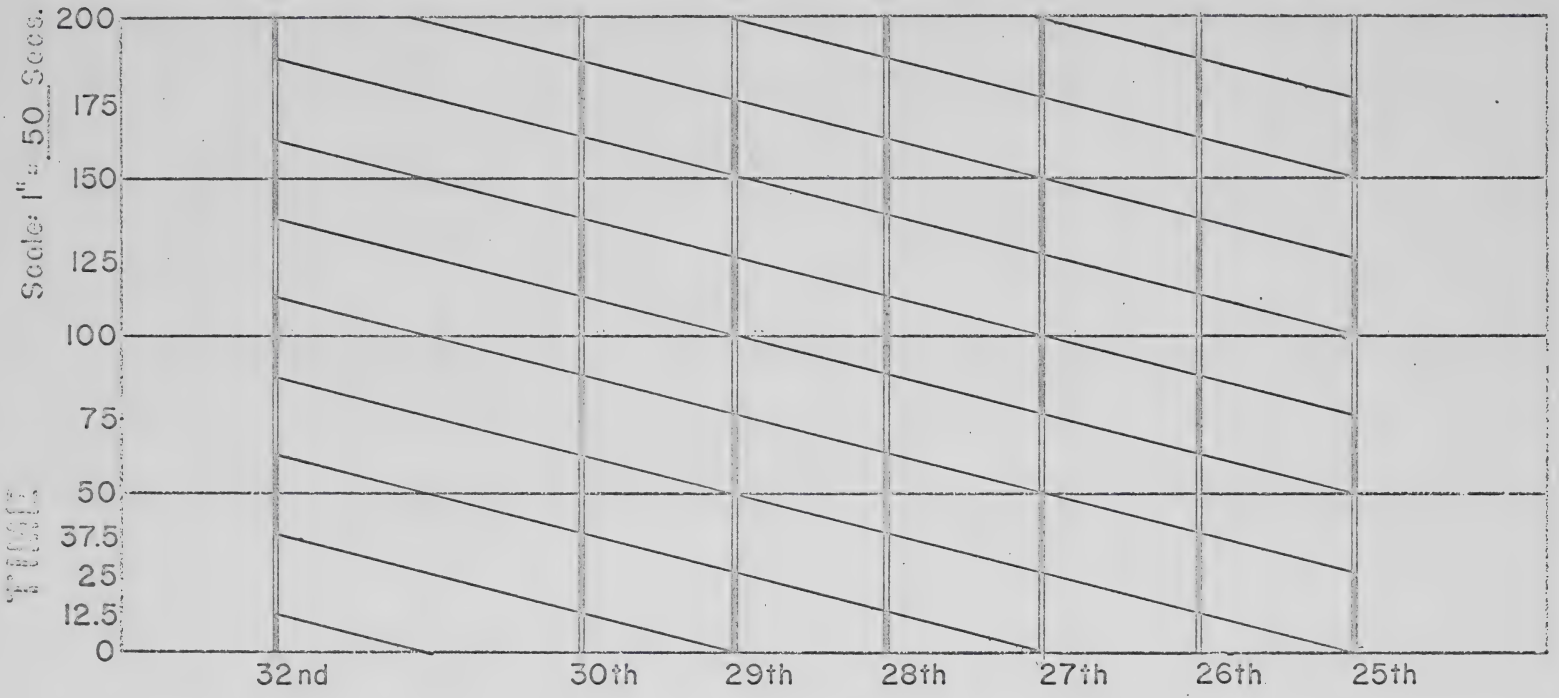
Fifty second cycle, 50-50 split
(Offset in seconds)
(East-west green in relation to east-west green at master)

	32nd Street	31st Street	30th Street	29th Street	28th Street	27th Street	26th Street
Sixth Avenue N	-	-	0	37.5	25.0	12.5	-
Fourth Avenue N	25.0	-	0	12.5	25.0	37.5	-
Third Avenue N	-	-	37.5	25.0	12.5	0	37.5
Second Avenue N	-	-	25.0	37.5	0	12.5	25.0
First Avenue N	37.5	-	12.5	0	37.5	25.0	12.5
Montana	-	-	0	12.5	25.0	37.5	-
Minnesota	-	-	-	-	-	-	-
First Avenue S	-	-	-	37.5	12.5	12.5	-

SIGNAL PROGRESSION CHART

1st Ave. N.

Signal Cycle 50 Secs. Progression Speed 21 M.P.H. Cycle Split 50:50 Thru Band 21.5 Secs.



DISTANCE

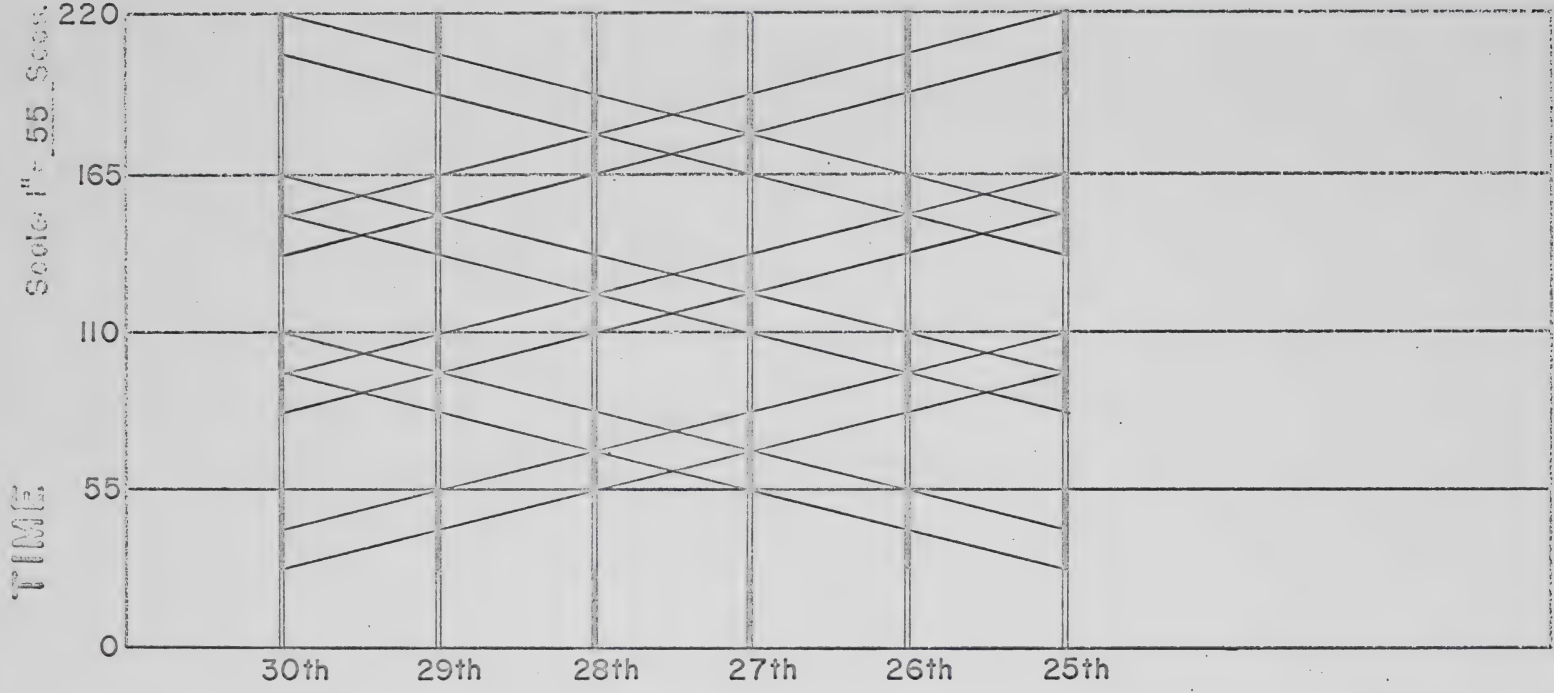
Scale: 1" = 380'

FIG. 7

SIGNAL PROGRESSION CHART

1st Ave. N.

Signal Cycle 55 Secs. Progression Speed 19 M.P.H. Cycle Split 50:50 Thru Band 13.8 Secs.



DISTANCE

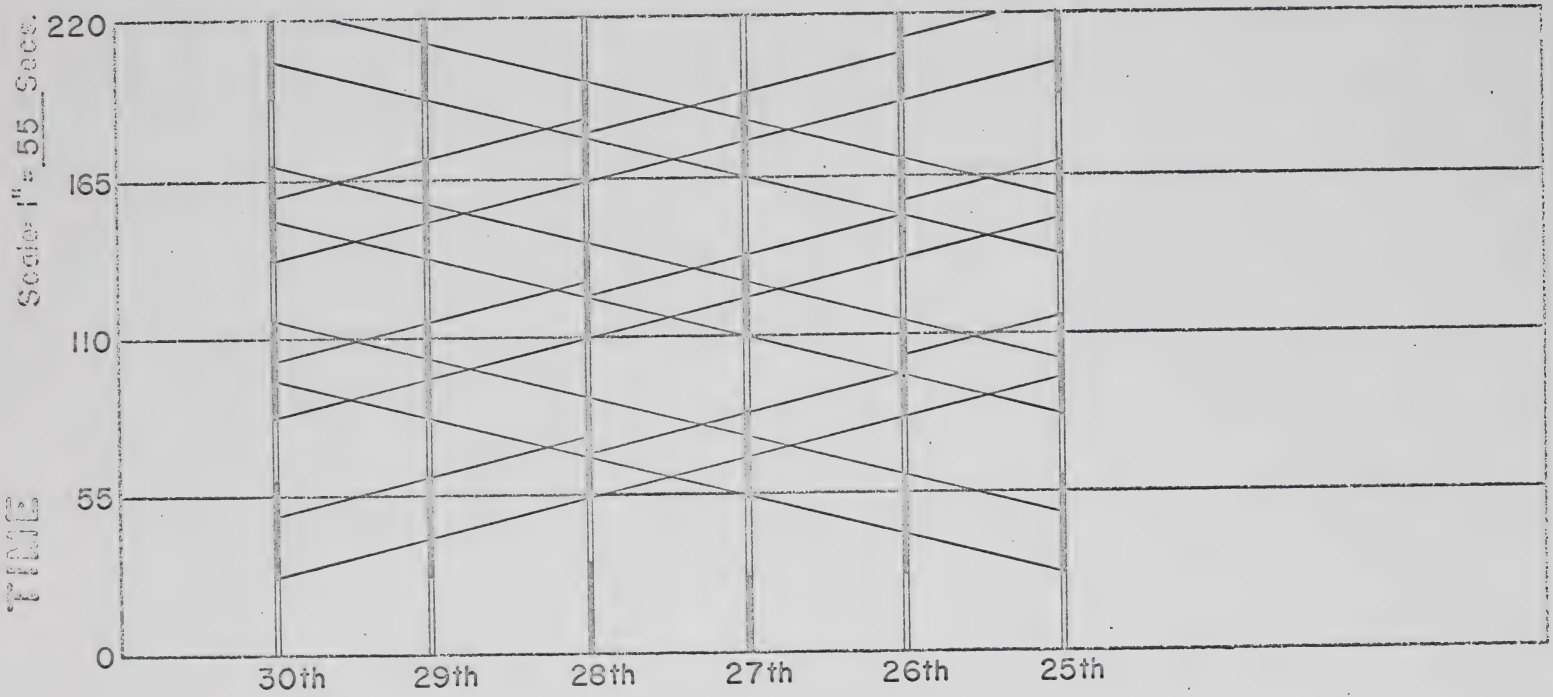
Scale: 1" = 380'

FIG. 8

SIGNAL PROGRESSION CHART

1st Ave. N.

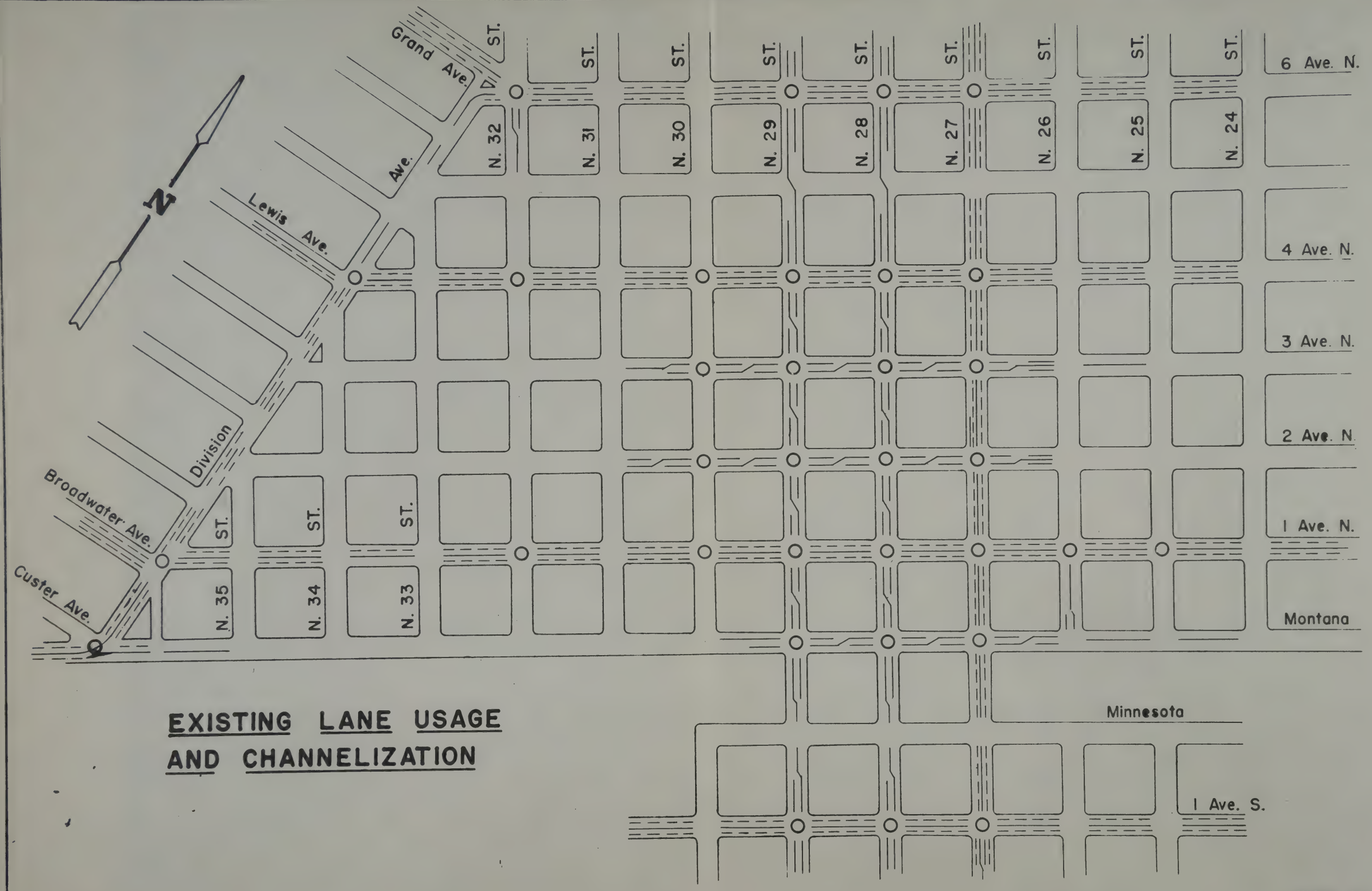
Signal Cycle 55 Secs. Progression Speed 19 M.P.H. Cycle Split 60:40 Thru Band 19.3 Secs.



DISTANCE

Scale: 1" = 380'

FIG. 9



EXISTING LANE USAGE AND CHANNELIZATION

FIG. 10

should be used as a permanent type of interconnection. A second alternate is overhead cable. The advantage of the cable is that it is a reliable simple system exclusively for the use of signal control. The disadvantages of the underground cable are the initial high cost if the undergrounding cannot be done in conjunction with street widening and paving.

At present, 18 of the intersections in the Central system are interconnected by underground conduit and cable. The City of Billings should continue to install underground cable whenever it is economically feasible in conjunction with street widening, sewer lines or storm drain construction. A good example of this was the installation of interconnect cable during the recent widening of North 27th Street.

Leased telephone lines have proved an excellent system where reasonable rates can be obtained and where a limited number of functions are needed to be transmitted. If a large number of functions are needed, either a large number of lines must be rented or expensive encoding and decoding equipment will be needed to transmit on a single pair of wires.

A contact with the telephone company should be made to determine the feasibility of leasing lines to include a long term contract and cost per mile per month. Unless extensive utility ducts are available or can be installed at little cost to the City, the leased lines are preferred and are reliable. They are compatible with the present system.

Radio control using frequency modulated radio to transmit tone signals to local intersection receivers has also been applied successfully. The greater complexity requires maintenance men of higher skills. The initial cost may be less but maintenance costs will exceed those of cable interconnection. Local contract prices would be needed to determine the type of system that would best suit Billings.

It is recommended that the use of leased telephone lines be pursued as the means of interconnection. An initial contact with Mr. E. L. (Lew) Allsup,

Communications Consultant with Mountain States Telephone Company, has been made. The cost of leasing a pair of telephone lines would be $1.25/ half-mile/month with a one-time charge of $10 per signal installation for connection charge.

The cost to install conduit would probably exceed four times the cost of telephone interconnect. To connect the outlying signals about four miles of interconnect would be needed. This cost would be less than $300 for the first year. Details of this type of interconnect must be negotiated with Mountain States Telephone Company and auxiliary equipment to provide "fail safe" operation must be installed. This normally involves a time delay monitor which frees the system should a lack of sync pulse be detected.

Radial Arterials

Signal system improvements outside the central area can be grouped into basically three groups. They are the Division Street system, the West Central System, the U. S. Highway 10 and 12 system and the Sixth Street West system.

Division Street System. The complex intersections along Division Street require multi-phase operation and are therefore limited in their total capacity by this requirement for multi-phases. The most efficient equipment available should be used for control purposes. A traffic actuated system is indicated from traffic volume information available. The system would require fully actuated equipment with northbound progression in the morning and southbound progression in the evening. This system is currently under design under another contract.

West Central System. Four of the six signals on Grand Avenue in the West Central System are placed on increments of one-quarter mile spacing. If there were no signal at Sixteenth Street and if the signal at Eighth Street were located at Ninth Street, a perfect progression for both directions at the speed limit of 35 m.p.h. could be obtained. This street forms the

SIGNAL PROGRESSION CHART

GRAND AVE. (Off Peak)

Signal Cycle 50 Secs. Progression Speed 36 M.P.H. Thru Band 10 Secs.

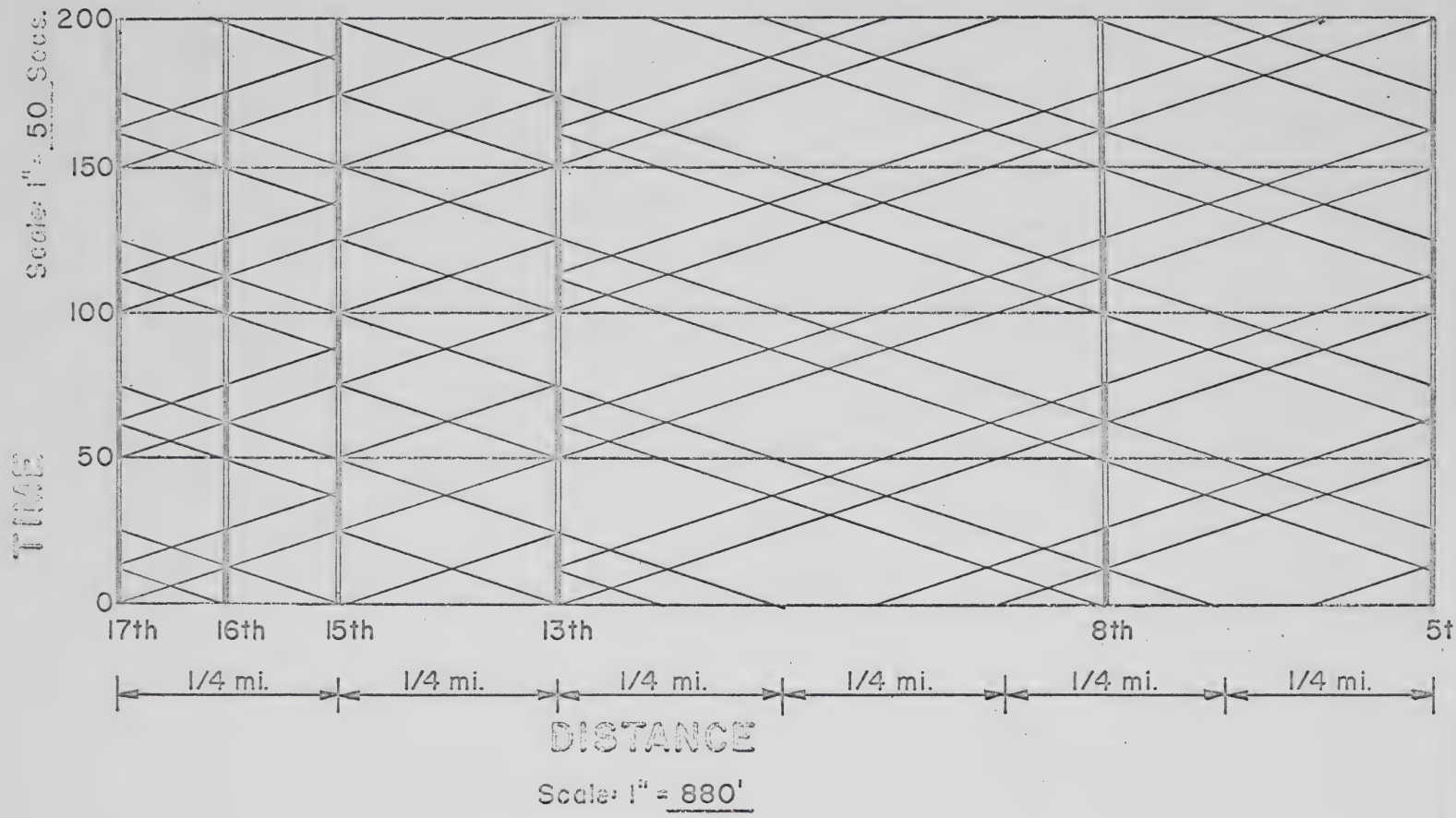


FIG. 11

SIGNAL PROGRESSION CHART

GRAND AVE. (A.M. Peak)

Signal Cycle 50 Secs. Progression Speed 36 M.P.H. Thru Band ____ Secs.

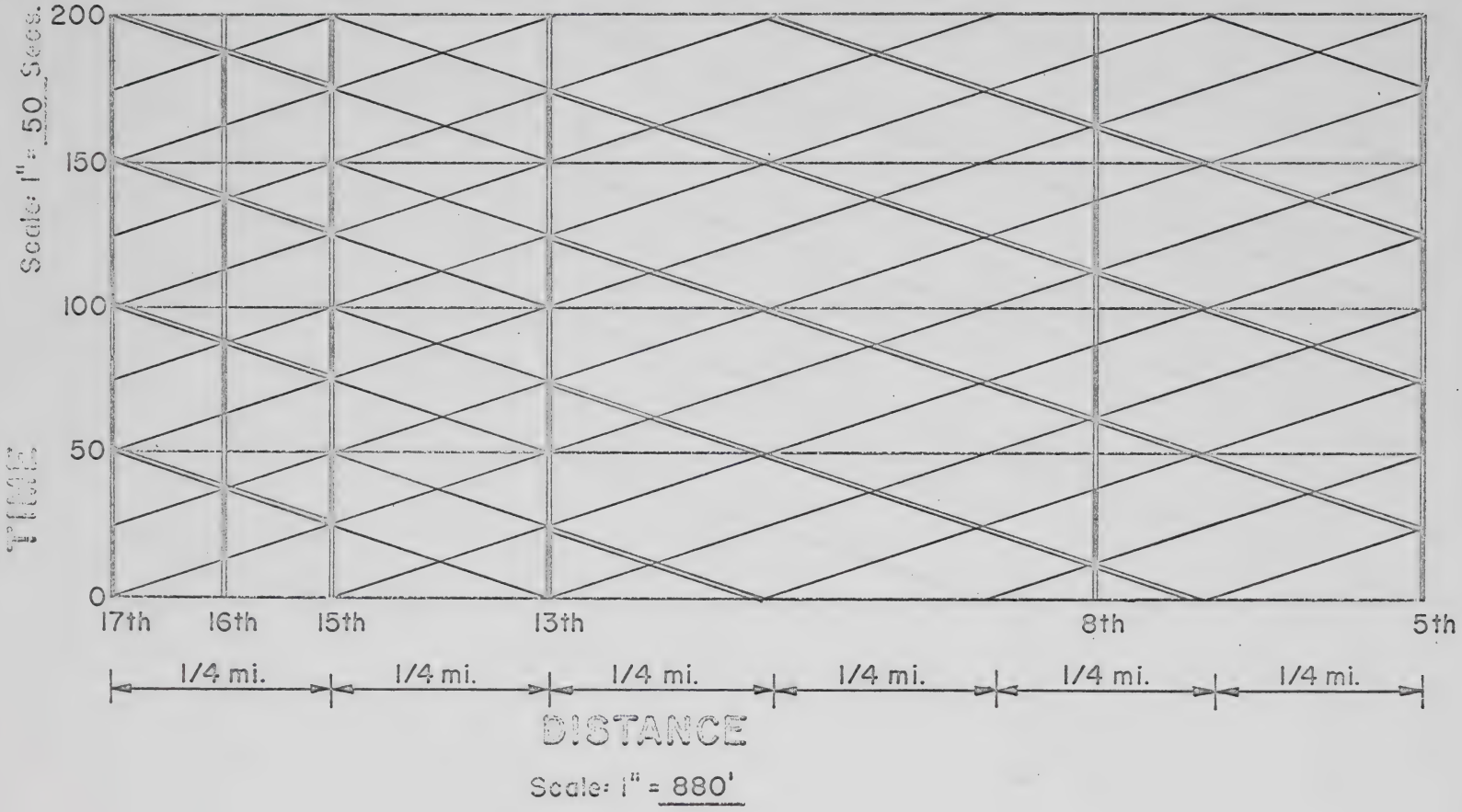


FIG. 12

SIGNAL PROGRESSION CHART

GRAND AVE. (P.M. Peak)

Signal Cycle 50 Secs. Progression Speed 36 M.P.H. Thru Band ____ Secs.

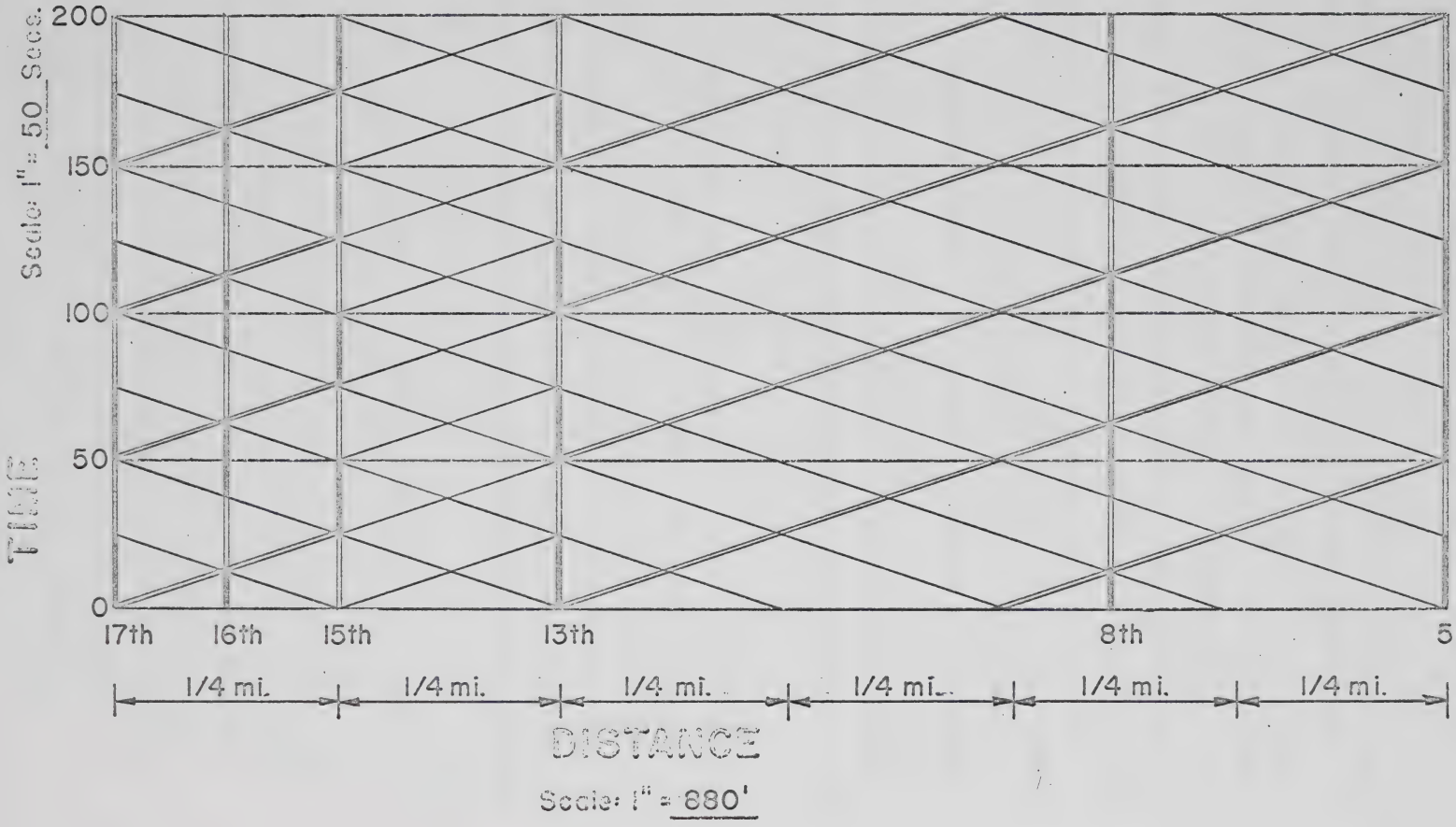


FIG. 13

basic pattern for the west central area. It is not proposed that Ninth Street West be made an arterial or that the signal at Eighth Street West be relocated. This fact of being able to obtain perfect progression at Ninth Street West is brought out only to illustrate the point that the signals in the West Central System are not on an ideal spacing, hence less than desirable operation is built into the system and must be recognized. This system should operate on a fifty second background cycle with traffic signals on the one-half mile spacing operating simultaneously and those on the one-quarter mile at a 50 percent offset. The signal at 16th Street, due to its one-eighth mile location, should be converted to a semi-actuated operation and progressed in the direction of major flow. Similarly the signal at Eighth Street, due to its one-eighth mile location, should be converted to a semi-actuated controller with progression to favor major flow. The intersections on Broadwater at Sixteenth, Eighth and Fifth Streets should be included in this system along with the intersection of Fifth Street and Lewis.

Figures 11, 12 and 13 show possible progression on Grand Avenue from 17th Street West through Fifth Street West for off-peak, A.M. peak and P.M. peak conditions. The off-peak setting is one which should be used at all times when the directional volumes are not critical. It is possible that under the current volume conditions this would be the only setting needed. As can be noted from the progression charts, favoring one direction penalizes the opposing directions of flow.

Table F shows the required offsets for the West Central System. Additional cycle lengths (55-60 sec) could be used but would produce lower travel speeds. As volumes build up in the future, the expansible controllers can be programmed in a similar manner for longer cycle lengths as a lower travel speed will become more acceptable. Until such time when more than one cycle length is needed, a single telephone pair can be used with one wire used for synchronization and one for dial transfer. At the intersections on Eighth Street and Sixteenth Street West the second dial transfer could be made by time clock. If a reasonable contract could be negotiated, a

TABLE F

SIGNAL OFFSETS - WEST CENTRAL SYSTEM

East-West Offsets (seconds) using Fifth & Grand Ave. Zero

	17th Street	16th Street	15th Street	13th Street	8th Street	5th Street
Grand Ave.	0	27	25	0	21	0
Lewis	-	0	-	-	-	0
Broadwater	-	0	-	-	21	0

Offsets on Sixteenth and Grand and Eighth at Grand & Broadwater are to the beginning of east-west amber as this is yield point for semi-actuated controllers.

Morning Peak

Grand Ave.	0	40	25	0	33	0
Lewis	-	12	-	-	-	0
Broadwater	-	12	-	-	33	0

Afternoon Peak

Grand Ave.	0	18	25	0	13	0
Lewis	-	35	-	-	-	0
Broadwater	-	35	-	-	13	0

telephone interconnect would prove to be the best solution to interconnecting this outlying area. See interconnect recommendation, CBD System.

U. S. Highway 10 and 12 System. The semi-actuated controller at the four intersections of U. S. Highway 10 and 12 with Sixth Avenue North, Lake Elmo Drive, State Route No. 3 and Wicks Lane is the most appropriate system for the foreseeable future and no additional equipment should be needed for control purposes. Final adjustment of the system should be determined in the field. Due to the complexity of actuated equipment, it should be field checked frequently to assure it is operative as required. During the field check of this equipment, one location was found to be malfunctioning.

Sixth Street West System. The Sixth Street West System consists of the two intersections on Sixth Street West at Central Avenue and Minnesota Avenue. The current intersections are operating at level of service "B" and "C" as defined by Highway Capacity Manual, Figure 14. However, the 1990 projected volumes will require considerable modification to the intersection geometrics and traffic signals, as shown in Figures 15 and 16. This design better fits the demand and volumes projected. A fully actuated traffic signal system would be preferable as these signals operate as an isolated pair and would not need coordination into any other system. A three phase controller at Central could control both intersections north of U.S. 10 with Phase A being the eastbound to southbound and left turn phase. The intersection at Minnesota will require a four phase operation with the southbound left turn and thru movement being Phase A. The coordination point on this equipment is from Phase A amber so a basic progression could be achieved from eastbound Central thru to eastbound Minnesota Avenue as this is the predominant flow. A single offset of about 14 seconds, i.e., southbound Minnesota 14 seconds after southeast bound Central, would be adequate as the westbound P.M. traffic arrives at random and has a free right turn. It would be possible to include an eastbound left turn access to the Montana Street on-ramp. This will enable movement from Central Avenue to Montana Street.

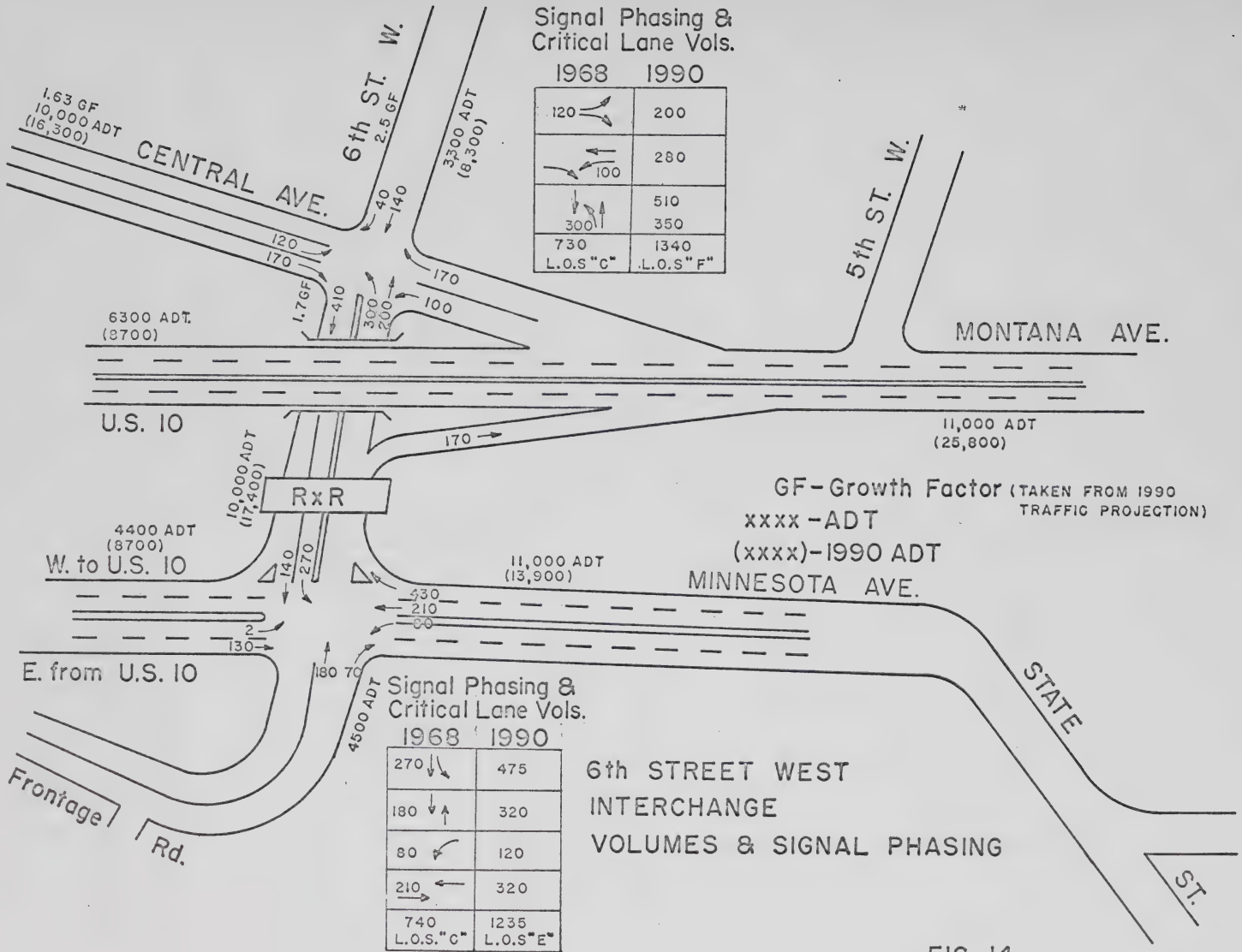

Signal Phasing & Critical Lane Vols.
1968 1990
120 200
100 280
300 510 350
730 L.O.S "C" 1340 L.O.S "F"
1.63 GF
10,000 ADT
(16,300)
CENTRAL AVE.
6th ST. W.
2.5 GF
3300 ADT
(8,300)
40
140
120
170
1.7GF
410
300
200
170
100
6300 ADT.
(8700)
5th ST. W.
MONTANA AVE.
U.S. 10
11,000 ADT
(25,800)
170
10,000 ADT
(17,400)
RxR
GF-Growth Factor (TAKEN FROM 1990 TRAFFIC PROJECTION)
xxxx-ADT
(xxxx)-1990 ADT
4400 ADT
(8700)
W. to U.S. 10
140
270
11,000 ADT
(13,900)
MINNESOTA AVE.
430
210
00
2
130
E. from U.S. 10
180
70
4500 ADT
Signal Phasing & Critical Lane Vols.
1968 1990
270 475
180 320
80 120
210 320
740 L.O.S."C" 1235 L.O.S"E"
Frontage Rd.
STATE
ST.
6th STREET WEST
INTERCHANGE
VOLUMES & SIGNAL PHASING

FIG. 14

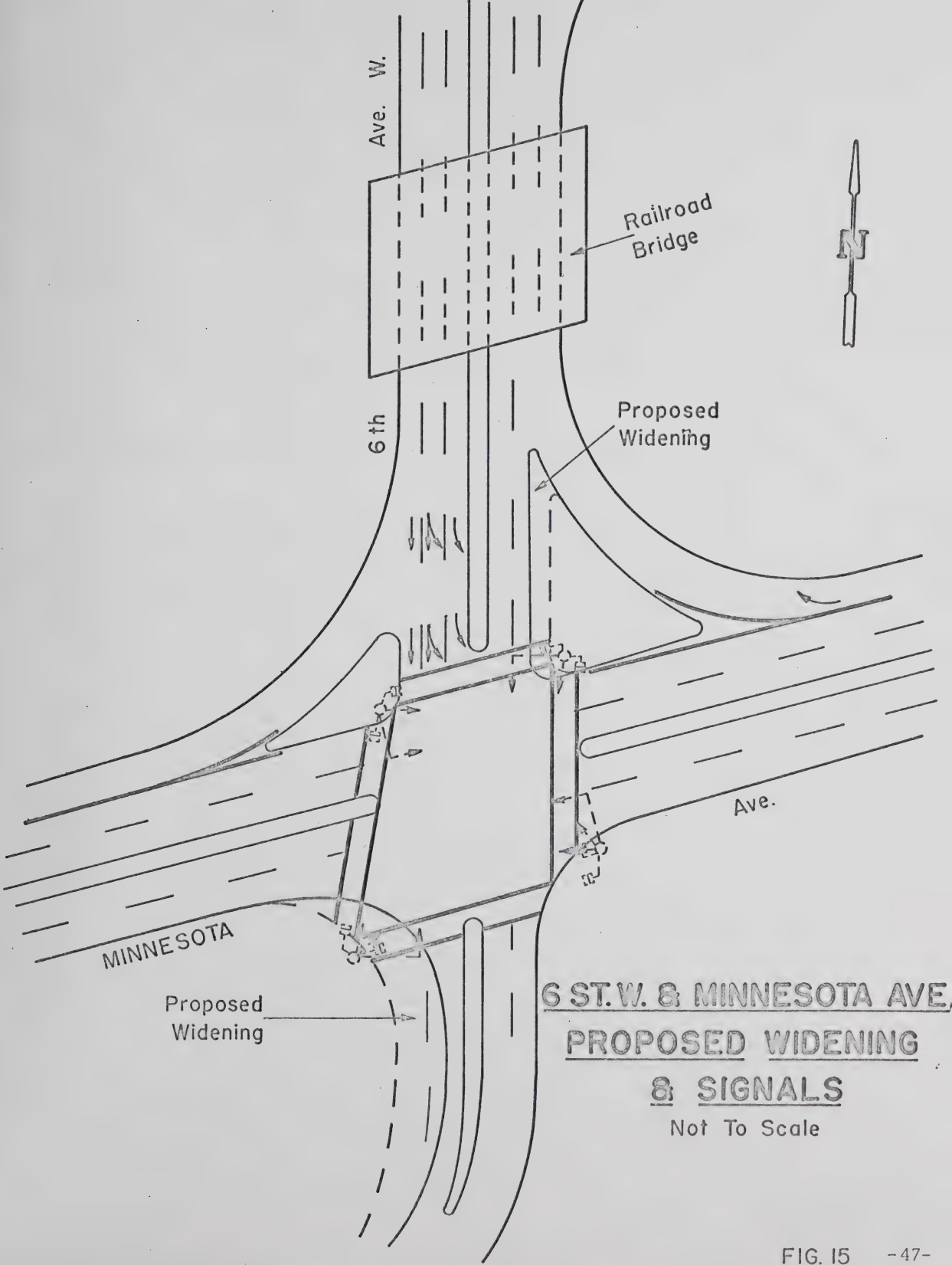
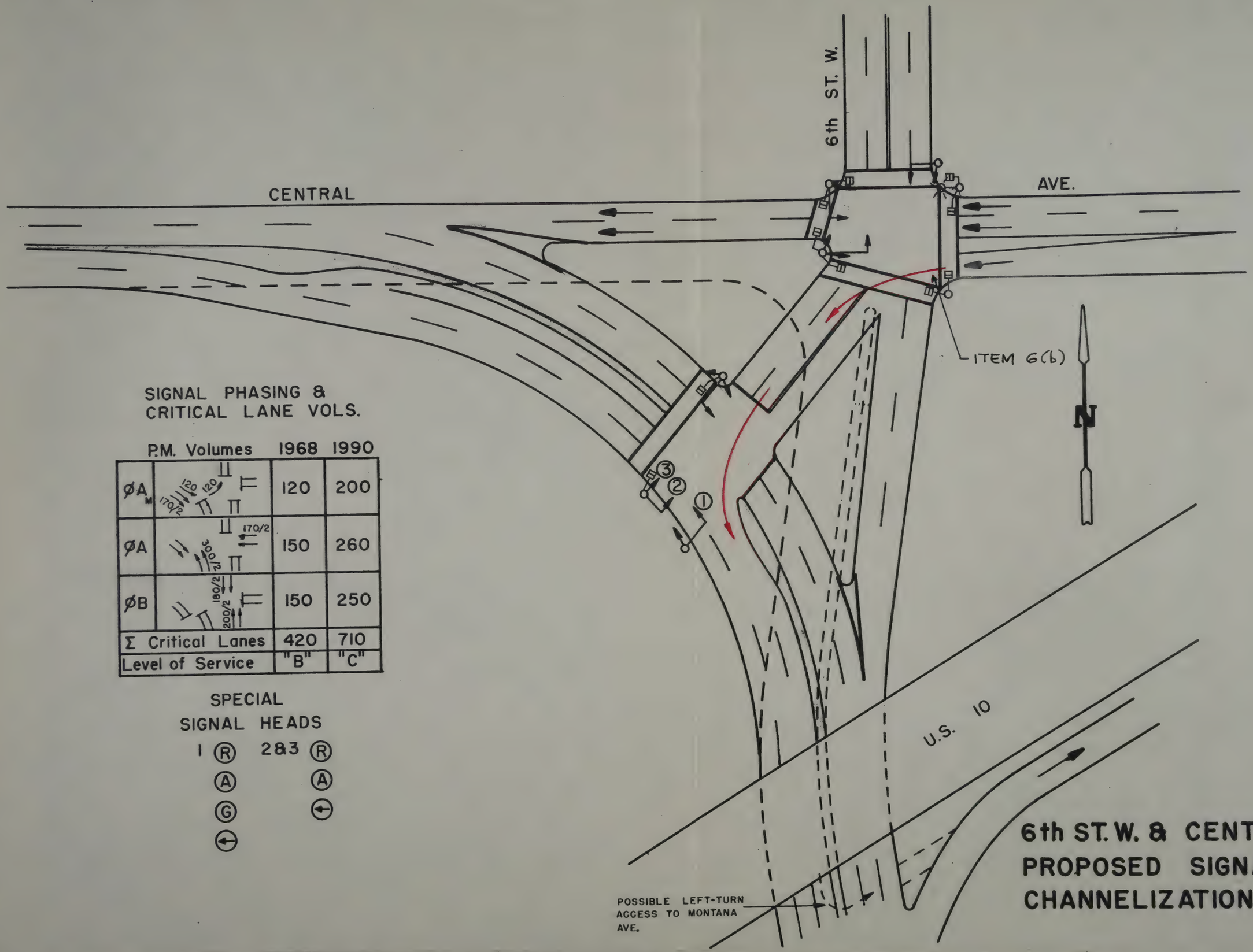

Ave. W.
Railroad Bridge
N
6th
Proposed Widening
Ave.
MINNESOTA
Proposed Widening
6 ST. W. & MINNESOTA AVE.
PROPOSED WIDENING
& SIGNALS
Not To Scale

FIG. 15



SIGNAL PHASING &
CRITICAL LANE VOLS.

P.M. Volumes		1968	1990
ØA	120 120 170/2	120	200
ØA	170/2 100	150	260
ØB	180/2 200/2	150	250
Σ Critical Lanes		420	710
Level of Service		"B"	"C"

SPECIAL
SIGNAL HEADS

1	2&3
R	R
A	A
G	←
←	

6th ST. W. & CENTRAL AVE. PROPOSED SIGNALS & CHANNELIZATION

FIG. 16 -48-

CHAPTER III

PROBLEM INTERSECTIONS

A field check of all signalized intersections has been made to determine possible improvements. Those intersections which were found to have operational problems were checked during peak traffic periods to ascertain the extent of problems and possible remedial treatments.

In addition to field observation, a capacity analysis was made of all locations using the "Highway Capacity Manual" in those critical locations where applicable and a Critical Lane analysis in other locations. Current volumes were analyzed along with projected volumes for 1990. Where the projected traffic volumes did not reflect the conditions which can be expected at some interim year, i.e., before the 1990 street system is fully constructed to relieve existing streets, the existing traffic volumes were normally factored by a three percent growth rate to obtain a volume figure which could be used to determine if the intersection and signal systems have adequate capacity to handle future traffic volumes. Table G shows this information. More detailed recommendations are also made on some of the critical intersections. Column "I" shows a level of service that could be expected if no change is made to the existing intersections.

In general, the signal installations in Billings are mechanically sound and well maintained; however, the most prominent limitation evident at many locations is the failure to apply sound traffic engineering techniques to intersections to be signalized.

It is not uncommon for citizen groups to demand a traffic signal as the cure-all for traffic ills where this is definitely not the case. Many studies reveal that traffic signals seldom reduce the total number of traffic accidents but only change their type. A traffic signal may induce traffic accidents and congestion if improperly installed.

The geometrics of many of the signalized intersections should be improved both for capacity and safety reasons. The easing of curb radius may allow a two-lane turn. The realignment of jog intersections will not only eliminate the head-on, side swipe and questionable right-of-way situations but will increase capacity as well. Specific examples are treated in the following recommendations for intersection improvement. It is further recommended that prior to any new intersection being signalized that curb alignment and other geometrics be improved to their ultimate. It is usually better to complete the improvement when there is a strong sentiment and justification for the signal than at some later date when the justification for realignment is less obvious to a non-professional. Funding for such projects is allowed under the current Federal "TOPICS" program if such intersections are on the Type 2 system. The City should be prepared to match any new Federal monies available for this purpose, and should have its Type 2 system approved at an early date.

TABLE G

	CURRENT CONDITIONS					INTERIM SYSTEM VOLUME				PROPOSED IMPROVEMENT	
Intersection code No.	No. of approach lanes E-W N-S Other	ADT E-W N-S Other Sum	P.H.V.[a] critical lanes E-W N-S Other Sum	Phasing and controller type	Level of service	ADT E-W N-S Other Sum	Growth Factor	Sum critical lanes V.P.H.	Level of service with no change	Lanes	Controller type & Phasing
A	B	C	D	E	F	G	H		I	J	K
1.	1 2	1,500 11,500 13,000	120 460/2 350	2 Ø F.T. 1 dial	A	3,000* 26,000 29,000	2.2	780	C	--	S.A. Dual max.
2.	2 2	13,000 12,000 25,000	420/2 460/2 440	2 Ø F.T. 1 Dial	B	20,000* 27,000 47,000	1.9	840	D	Left turn NS-EW or 1-way	3 Dial ** 3 offset F.T. Ped. signals
3.	2 1 + LTC 2	14,000 5,000 12,000 31,000	420 250 200 870	3 Ø F.T. 3 dial	D	20,000* 10,000* 20,000* 50,000	1.6	1400	F	Widen for W.B. or 1-way	F.A. **
4.	2 1 + LTC	13,000 4,000 17,000	330 180 510	2 Ø F.T. 1 dial	B	20,000* 8,000* 28,000	1.6	820	D	Widen 6th for 2-way lt. L or 1-way	3 Dial 3 offset F.T.
5.	2 1 + LTC	13,000 5,000 18,000	320 220 540	2 Ø F.T. 1 Dial	B	20,000* 10,000* 30,000	1.7	920	D	Widen 6th for 2-way lt L. or 1-way	3 Dial 3 offset F.T.
6.	1 1	1,000 4,000 5,000	75 150 225	Flasher	A	1,500 6,000 7,500	1.5	340	A	--	**
7.	2 1	6,000 1,000 7,000	360/2 75 255	Flasher	A	17,000 2,000 19,000	2.7	690	C	--	3 Dial 3 offset F.T.

Intersection code No.	CURRENT CONDITIONS: No. of approach lanes E-W / N-S / Other	ADT E-W / N-S / Other / Sum	P.H.V.[a] critical lanes E-W / N-S / Other / Sum	Phasing and controller type	Level of service	INTERIM SYSTEM VOLUME: ADT E-W / N-S / Other / Sum	Growth Factor	Sum critical lanes V.P.H.	Level of service with no change	PROPOSED IMPROVEMENT: Lanes	Controller type & Phasing
A	B	C	D	E	F	G	H		I	J	K
8.	2 2 2	4,000 6,000 10,000 20,000	180 360/2 600/2 660	3 Ø F.T. 1 Dial	B	6,000 10,000* 15,000* 31,000	1.5	990	D	Improved Geometrics	F.A. ** 3 Phase
9.	2 1	9,500 5,000 14,500	240 250 490	2 Ø F.T. 1 Dial	B	14,000* 7,500* 21,500	1.5	730	C	-	3 Dial 3 Offset F.T.
10.	2 1	9,000 5,000 14,000	220 250 470	2 Ø F.T. 1 Dial	B	13,500* 7,500* 21,000	1.5	710	C	-	3 Dial 3 Offset F.T.
11.	2	9,000 5,000 14,000	220 230 450	2 Ø F.T.	B	13,500* 7,500* 21,000	1.5	680	C	-	3 Dial 3 Offset F.T.
12.	2 1 + LTC	8,500 7,000 15,500	210 330 540	2 Ø F.T. 1 Dial	B	12,500 10,500* 23,000	1.5	810	D	-	3 Dial 3 Offset F.T.
13.	2 2	8,000 12,000 20,000	370/2 425/2 400	2 Ø F.T. 1 Dial	B	12,000* 30,000 42,000	2.1	840	D	-	3 Dial 3 Offset F.T. Ped. Signals
14.	1 + LTC 1	6,500 5,000 11,500	290 250 540	2 Ø F.T. 1 Dial	C	9,500 7,500* 17,000	1.5	810	D	-	3 Dial 3 Offset F.T.
15.	1 + LTC 1 + LTC	6,500 5,000 11,500	290 230 520	2 Ø F.T. 1 Dial	B	10,000 7,500* 17,500	1.5	780	C	-	3 Dial 3 Offset F.T.

Intersection code No.	No. of approach lanes E-W / N-S / Other	CURRENT CONDITIONS ADT E-W / N-S / Other / Sum	P.H.V. critical lanes E-W / N-S / Other / Sum	Phasing and controller type	Level of service	INTERIM SYSTEM VOLUME ADT E-W / N-S / Other / Sum	Growth Factor	Sum critical lanes V.P.H.	Level of service with no change	PROPOSED IMPROVEMENT Lanes	Controller type & Phasing
A	B	C	D	E	F	G	H		I	J	K
16.	1 + LTC 1 + LTC	5,000 7,000 12,000	230 310 540	2 Ø F.T. 1 Dial	B B	10,000 10,000* 20,000	1.8	970	D	-	3 Dial 3 Offset F.T.
17.	1 + LTC 2	4,500 12,000 16,500	230 440/2 450	2 Ø F.T. 1 Dial	B	7,000* 25,000 32,000	1.9	850	D	-	3 Dial 3 Offset
18.	1 + LTC 1	5,500 4,000 9,500	250 200 450	2 Ø F.T. 1 Dial	B	8,000* 6,000* 14,000	1.5	680	C	-	3 Dial 3 Offset F.T.
19.	1 + LTC 1 + LTC	6,500 6,000 12,500	290 270 560	2 Ø F.T. 1 Dial	B	10,000* 9,000* 19,000	1.5	840	D	-	3 Dial 3 Offset F.T.
20.	1 + LTC 1 + LTC	6,500 7,500 14,000	290 340 630	2 Ø F.T. 1 Dial	C	10,000* 11,000* 21,000	1.5	950	D	-	3 Dial 3 Offset F.T.
21.	1 + LTC 2	5,000 11,500 16,500	250 560/2 530	2 Ø F.T. 1 Dial	B	7,500* 24,000 31,500	1.9	1000	E	-	3 Dial 3 Offset F.T
22. 50.	2 2 2	9,000 9,000 8,000 26,000	440/2 490/2 220/2 575	3 Ø F.T. 3 Dial	B	11,500 18,000 17,000 46,500	1.8	1030	E	-	Under study by M & M Ped. signals
23.	2 1	11,500 2,000 13,500	540/2 90 360	2 Ø F.T. 1 Dial	A	18,000 3,000* 21,000	1.6	580	B	-	3 Dial** 3 Offset F.T.

Intersection code No.	No. of approach lanes E-W N-S Other	CURRENT CONDITIONS ADT E-W N-S Other Sum	P.H.V. critical lanes E-W N-S Other Sum	Phasing and controller type	Level of service	INTERIM SYSTEM VOLUME ADT E-W N-S Other Sum	Growth Factor	Sum critical lanes V.P.H.	Level of service with no change	PROPOSED IMPROVEMENT Lanes	Controller type & Phasing
A	B	C	D	E	F	G	H		I	J	K
24.	2 1	13,000 4,000 17,000	600/2 230 530	2 Ø F.T. 1 Dial	B	18,500 6,000* 24,500	1.4	740	C	-	3 Dial 3 Offset F.T.
25.	2 1 + LTC	13,000 6,000 19,000	620/2 250 560	2 Ø F.T. 1 Dial	B	19,000 9,000* 28,000	1.5	840	D	-	3 Dial 3 Offset F.T.
26.	2 1 + LTC	13,000 7,500 20,500	460/2 330 560	2 Ø F.T. 1 Dial	C	19,000 12,000 31,000	1.5	840	D	-	3 Dial 3 Offset F.T.
27.	2 2	13,500 11,500 25,000	400/2 300/2 350	2 Ø F.T. 1 Dial	A	20,500 17,000 37,500	1.5	520	B	-	3 Dial 3 Offset F.T.
28.	2 1	13,500 4,500 18,000	510/2 130 385	2 Ø F.T. 1 Dial	A	19,500 7,000* 26,500	1.5	580	B	-	3 Dial 3 Offset F.T.
29.	2 1	10,000 2,000 12,000	390/2 80 275	2 Ø F.T. 1 Dial	A	20,000 3,000 23,000	1.9	520	B	-	3 Dial 3 Offset F.T.
30.	2 1	14,000 8,000 22,000	500/2 330/2 260 675	3 Ø F.T. 1 Dial	C	30,500 7,000 37,500	1.7	1150	E	-	3 Phase F.A. Under study by M & M
31.	2 2	11,000 8,000 7,000 26,000	270/2 460/2 365	2 Ø F.T. 3 Dial	B	30,000 18,000 12,000 60,000	2.3	840	D	-	2 Phase F.A. Under study by M & M

	CURRENT CONDITIONS					INTERIM SYSTEM VOLUME				PROPOSED IMPROVEMENT	
Intersection code No.	No. of approach lanes E-W N-S Other	ADT E-W N-S Other Sum	P.H.V.[a] critical lanes E-W N-S Other Sum	Phasing and controller type	Level of service	ADT E-W N-S Other Sum	Growth Factor	Sum critical lanes V.P.H.	Level of service with no change	Lanes	Controller type & Phasing
A	B	C	D	E	F	G	H		I	J	K
32.	1 + LTC 1 + LTC	11,000 7,000 18,000	500 310 810	2 Ø F.T. 1 Dial	D	17,000* 10,000* 27,000	1.5	1200	E	-	3 Dial 3 Offset F.T.
33.	1 + LTC 1 + LTC	11,000 6,500 17,500	500 290 790	2 Ø F.T. 1 Dial	C	17,000* 10,000* 27,000	1.5	1200	E		3 Dial 3 Offset F.T.
34.	1 + LTC 2	9,000 8,500 17,500	400 420/2 610	2 Ø F.T. 1 Dial	C	13,000* 13,000 26,000	1.5	900	D	-	3 Dial 3 Offset F.T.
35.	2 1 + LTC	12,000 7,000 19,000	600/2 310 610	2 Ø F.T. 1 Dial	C	18,000* 10,000* 28,000	1.5	900	D	5 lane section E-W	3 Dial F.T.
36.	2 1 + LTC	12,000 5,500 17,500	600/2 250 550	2 Ø F.T. 1 Dial	B	18,000* 8,000* 26,000	1.5	820	D	5 lane section E-W	3 Dial F.T.
37.	2 2	12,000 8,500 20,500	600/2 420/2 510	2 Ø F.T. 1 Dial	B	18,000* 13,000* 31,000	1.5	750	C	5 lane section E-W Improve N-S alignment	3 Dial ** F.T. Ped. signal
38.	1 1	5,000 2,000 7,000	300 120 420	Flasher	B	14,000 3,500 17,500	2.5	1050	E	Improve E-W alignment	3 Dial ** 3 Offset F.T.
39.	2 1 1	8,500 4,000 4,000 16,500	310 310 170 790	3 Ø F.T. 1 Dial	C	13,000 6,500 6,500 26,000	1.6	1300	E	Improve E-W & N-S	F.A. ** Dual max. 3 Ø
40.	2 /	9,000 5,000 14,000	540/2 300 570	2 Ø F.T. 1 Dial	B	11,500 12,000 23,500	1.7	970	D	Improve N-S	F.T. ** 3 Dial 3 Offset

Inter-section code No.	CURRENT CONDITIONS: No. of approach lanes E-W N-S Other	ADT E-W N-S Other Sum	P.H.V.[a] critical lanes E-W N-S Other Sum	Phasing and controller type	Level of service	INTERIM SYSTEM VOLUME: ADT E-W N-S Other Sum	Growth Factor	Sum critical lanes V.P.H.	Level of service with no change	PROPOSED IMPROVEMENT: Lanes	Controller type & Phasing
A	B	C	D	E	F	G	H		I	J	K
41.	2 2	12,500 7,000 19,500	750/2 420/2 585	2 Ø F.T. 1 Dial	B	19,000* 10,000 29,000	1.5	880	D	Improve N. leg	3 Phase ** S.A. Dual max. Ped. signals
42.	2 2	13,000 3,500 16,500	780/2 210 600	2 Ø F.T. 1 Dial	B	19,500 5,000 24,500	1.5	900	D	-	3 Dial ** 3 Offset F.T. Ped. Signals
43.	2 2	16,500 4,500 21,000	990/2 270/2 630	2 Ø F.T. 1 Dial	C	24,000* 7,000* 31,000	1.5	945	D	-	S.A. ** Dual max. Ped. signals
44.	2 1	16,500 6,000 22,500	990/2 360 855	2 Ø F.T. 1 Dial	D	24,000 9,000* 33,000	1.5	1280	E	N-S realign.	3 Dial ** 3 Offset F.T. Ped. Signals
45.	1 1	1,500 6,000 7,500	90 360 450	Flasher	B	2,000* 8,000 10,000	1.4	630	C	-	S.A. **
46.	1 1	4,500 4,500 9,000	270 270 540	2 Ø F.T. 1 Dial	B	7,000* 7,000* 14,000	1.5	810	D	-	3 Dial ** 3 Offset F.T.
47.	1 1	8,500 6,500 15,000	510 390 900	2 Ø F.T.	D	12,000* 9,000 21,000	1.5	1350	E	-	3 Dial ** 3 Offset F.T.
48.	2 1	10,500 5,000 15,500	630/2 300 615	2 Ø F.T.	C	15,000* 7,500 22,500	1.5	900	D	-	S.A. ** Dual max.

	CURRENT CONDITIONS					INTERIM SYSTEM VOLUME				PROPOSED IMPROVEMENT	
Intersection code No.	No. of approach lanes E-W N-S Other	ADT E-W N-S Other Sum	P.H.V.[a] critical lanes E-W N-S Other Sum	Phasing and controller type	Level of service	ADT E-W N-S Other Sum	Growth Factor	Sum critical lanes V.P.H.	Level of service with no change	Lanes	Controller type & Phasing
A	B	C	D	E	F	G	H		I	J	K
49.	2 1	11,000 4,500 15,500	660/2 270 600	2 Ø F.T. 1 Dial	C	16,500 7,000 23,500	1.5	900	D	-	3 Dial 3 Offset F.T.
50.	See #22										
51.	2 2 2	9,900 10,100 3,400 23,400	170 440 170 780	3 Ø F.T. 3 Dial	C	16,300 17,400 5,800* 39,500	1.7	1,300	F	Realign Central to 6th	3 Ø ** F.A. dual max
53.	2 2	11,000 10,000 21,000	290 450 740	2 Ø F.T. 3 Dial	C	13,900 17,400 30,300	1.4	1,100	E	Widen N-S	4 Ø ** F.A. Dual max.
54.	2 1	12,500 2,000 14,500	375 120 495	2 Ø F.T. 1 Dial	B	19,000 3,500 22,500	1.6	790	C	Widen & align S leg	3 Dial 3 Offset F T.
55.	2 1	12,200 4,900 17,100	330 250 580	2 Ø F.T. 1 Dial	B	20,000* 8,000 28,000	1.6	930	D	Widen E-W or 1-way	3 Dial 3 Offset F T
56.	1 1	8,000 9,700 17,700	360 230 590	Flasher	B	32,000 17,500 49,500	2.8	1,600	F		Under design by M & M

[a] Existing counts used where available ADT factored for other counts

* Adjusted ADT figures for signal study to compensate for computor variance and Interim System

** See additional information in text

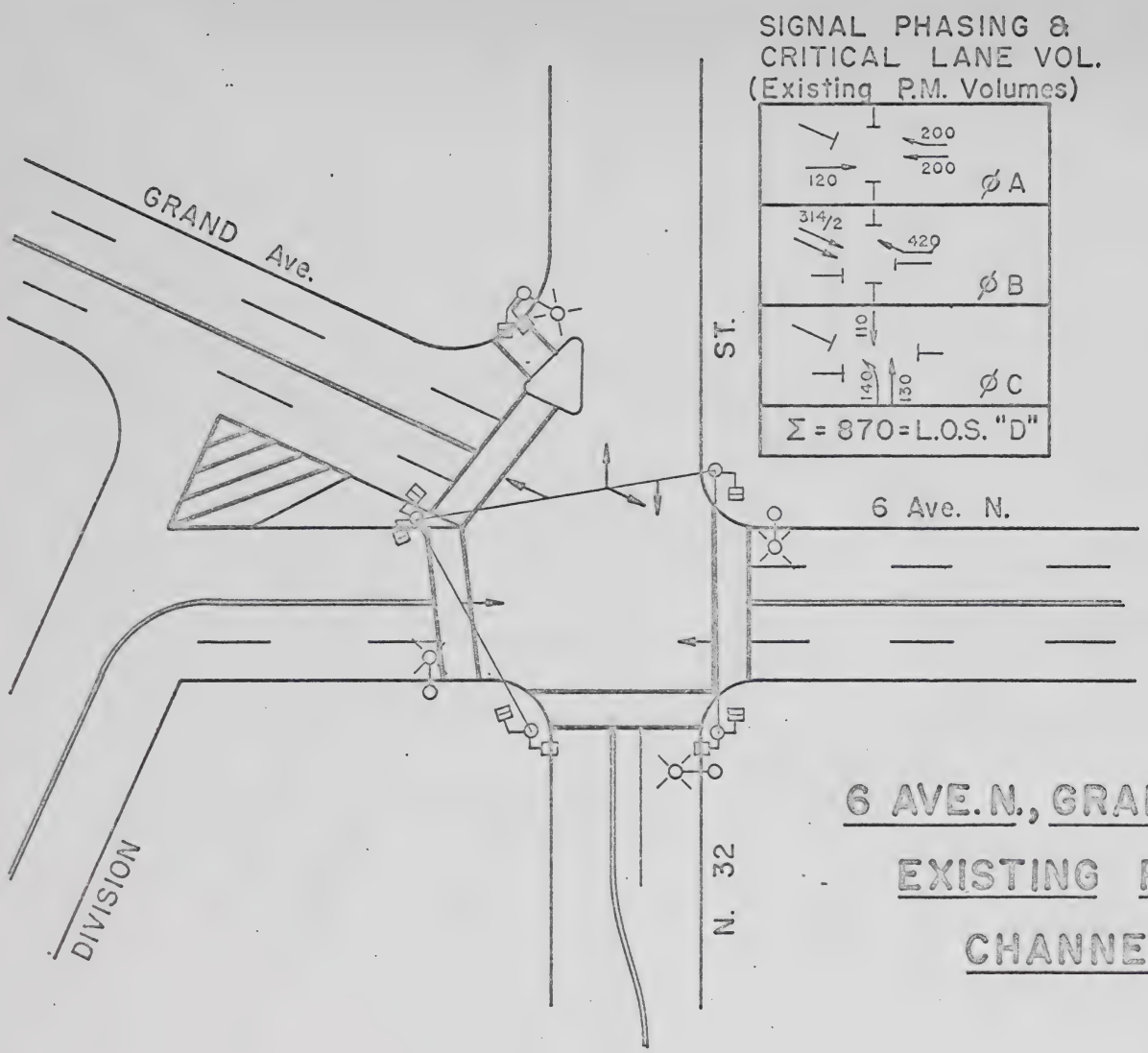
Intersection code No.	CURRENT CONDITIONS: No. of approach lanes E-W / N-S / Other	ADT E-W / N-S / Other / Sum	P.H.V.[a] critical lanes E-W / N-S / Other / Sum	Phasing and controller type	Level of service	INTERIM SYSTEM VOLUME: ADT E-W / N-S / Other / Sum	Growth Factor	Sum critical lanes V.P.H.	Level of service with no change	PROPOSED IMPROVEMENT: Lanes	Controller type & Phasing
A	B	C	D	E	F	G	H		I	J	K
57.	1 2	4,000 14,000 18,000	240 420 660	2 Ø S.A. Dual max.	C	15,600 23,400 39,000	2.2	1,450	F	6 la N-S 4 la E-W	**
58.	2 2 + LTC	2,000 16,000 18,000	120 480 600	2 Ø S.A. Dual max	C	5,000 34,500 39,500	2.2	1,300	F	6 la N-W	
59.	1 2 + LTC	1,500 15,000 16,500	90 450 540	2 Ø S.A. Dual max.	B	19,200 33,300 52,500	3.2	1,700	F	Widen all legs	**
60.	1 2 + LTC	2,300 10,000 12,300	140 300 440	Ø 4 S.A. Dual max.	B	7,800 22,100 29,900	2.4	1,100	E		

(2) Left turn volumes at this intersection are in the range of 20 percent both north-south and east-west. Therefore, as volumes increase in the future, either a left turn storage lane will be needed, i.e., five lanes, or a six-lane design. If the recommended one-way system is incorporated, the existing cross section on both streets should be adequate.

(3) Analysis of current volumes indicates that near capacity conditions exist, i.e., level of Service "D", as defined in Highway Capacity Manual, Figure 17. The one-way system as recommended, Figure 18, would operate at level of Service "B". If, however, the two-way system is to remain, then widening on the east leg will be needed and a level of Service "C" can be obtained, Figure 19. The problems with the current operation were found to be the restrictive geometrics for westbound traffic from Sixth Avenue North to Grand Avenue, causing heavy curb lane usage. Modification of signal indications, some curb cut-back on the south side of Sixth Avenue North at Division and island revision on North 32nd Street is also needed. If two-way operation is to remain, the eastbound to northbound left turn should be prohibited on Sixth Avenue North.

(6) Additional signal face needed for "C" Street.

(8) The curb return on the northwest corner of Lewis and Division should be cut back to allow two-lane westbound from Fourth Avenue to Lewis. By acquiring a triangle of property from The American Lutheran Church, the geometrics and capacity of this intersection could be greatly improved, Figure 20. This would assist in relieving traffic loads from Grand Avenue and Broadwater. The eastbound traffic signal indications are not in good alignment and are partially hidden on the approach by trees. If the jog is realigned, they should be relocated.



6 AVE. N., GRAND AVE., N. 32 ST.
EXISTING PHASING & CHANNELIZATION

FIG. 17

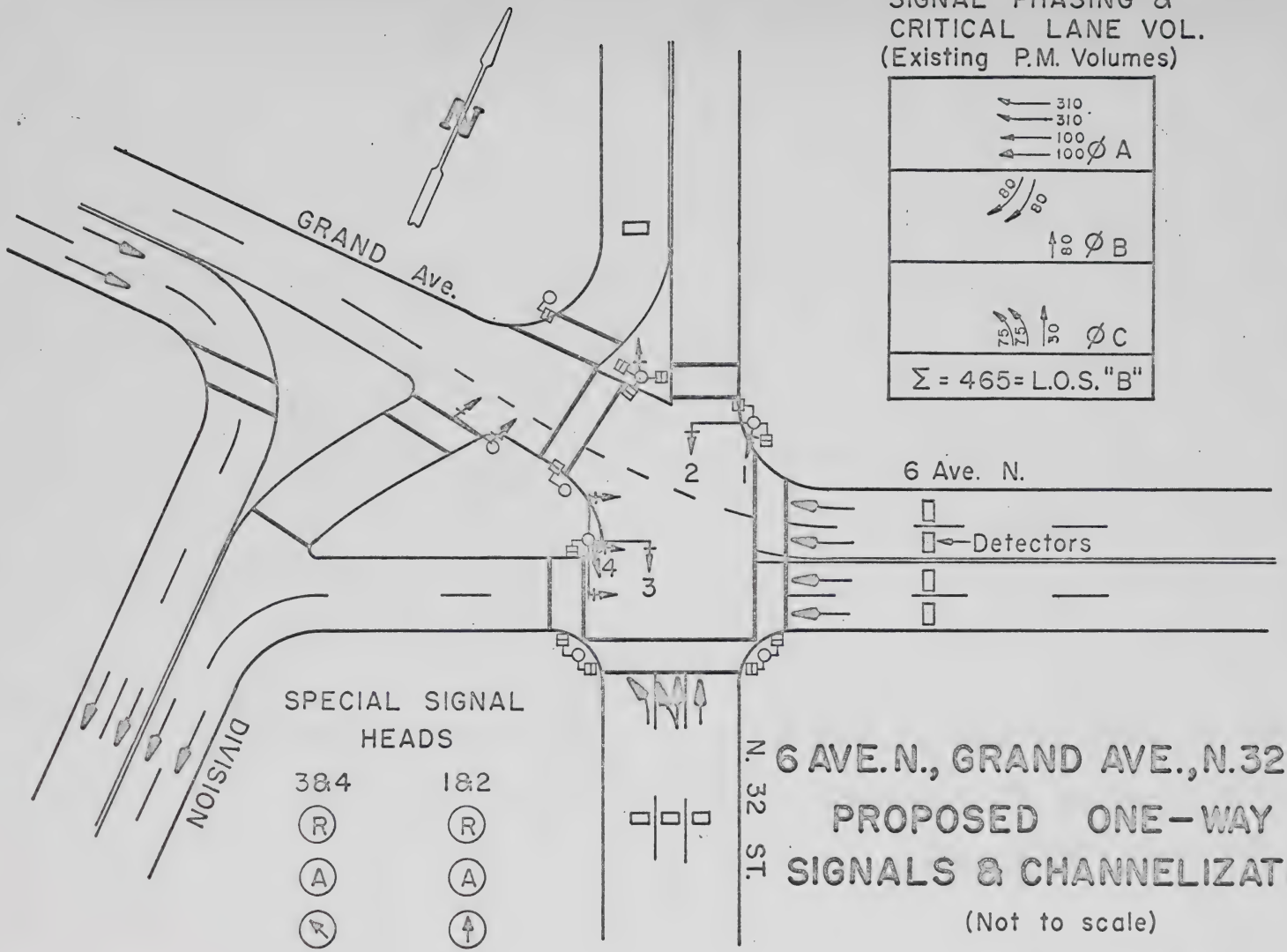

SIGNAL PHASING &
CRITICAL LANE VOL.
(Existing P.M. Volumes)
310
310
100
100 Ø A
80
80
80 Ø B
75
75
30 Ø C
Σ = 465 = L.O.S. "B"
GRAND Ave.
6 Ave. N.
Detectors
2
1
4
3
DIVISION
N. 32 ST.
SPECIAL SIGNAL
HEADS
3&4
1&2
R
A
6 AVE. N., GRAND AVE., N. 32 ST.
PROPOSED ONE-WAY
SIGNALS & CHANNELIZATION
(Not to scale)

FIG. 18

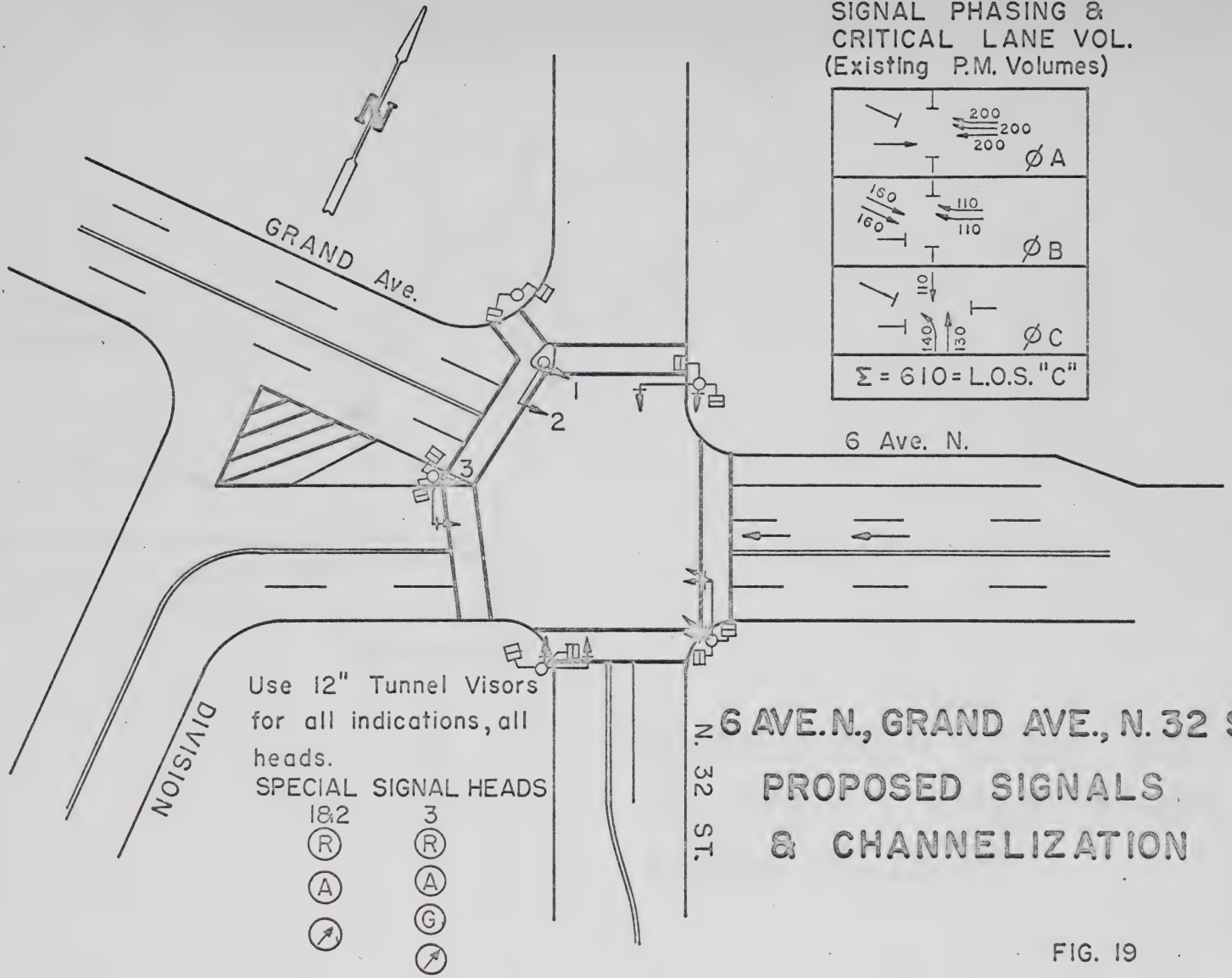
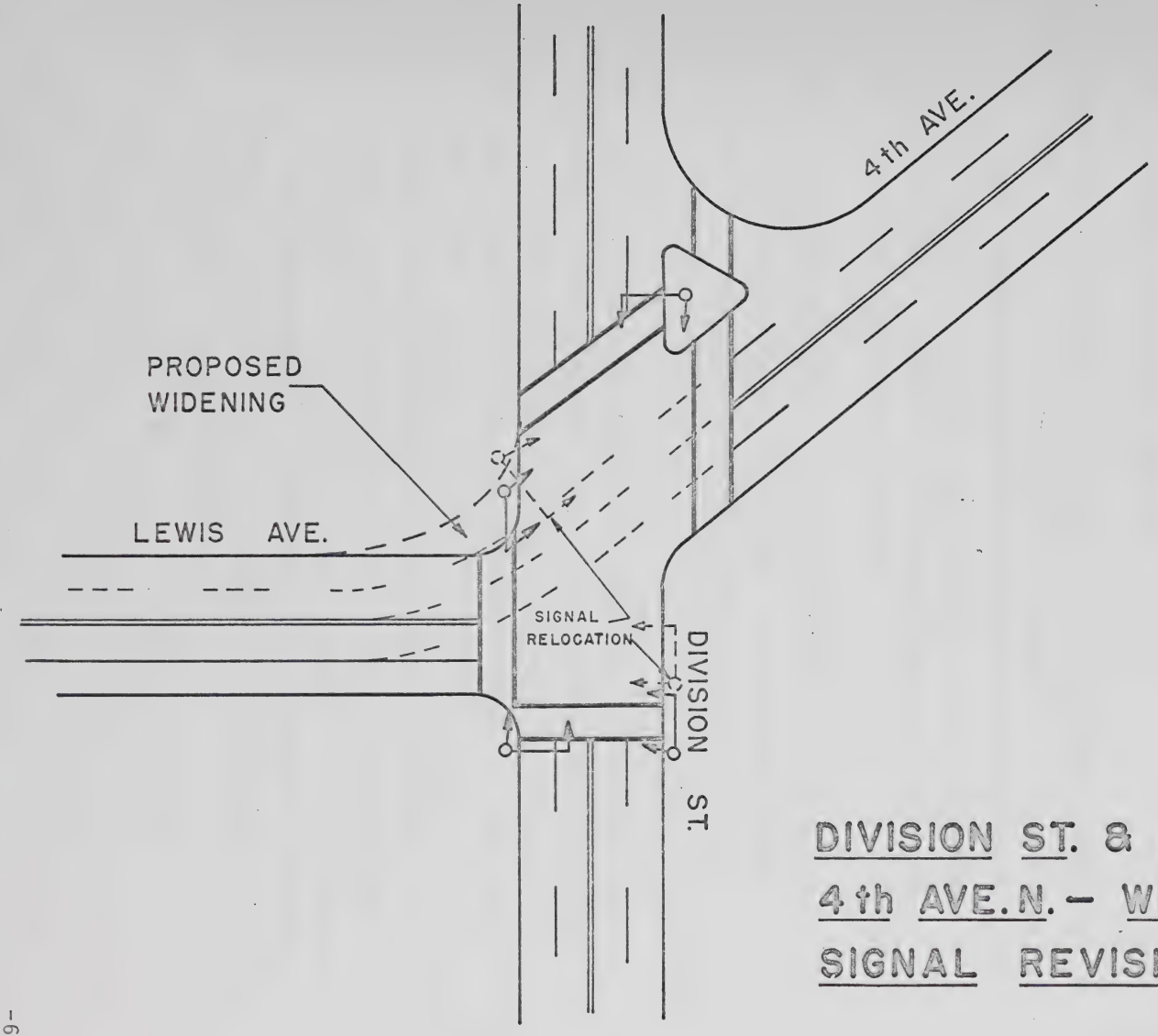

SIGNAL PHASING &
CRITICAL LANE VOL.
(Existing P.M. Volumes)
200
200
200
ØA
160
160
110
110
ØB
110
140
130
ØC
Σ = 610 = L.O.S. "C"
GRAND Ave.
6 Ave. N.
DIVISION
N. 32 ST.
1
2
3
Use 12" Tunnel Visors
for all indications, all
heads.
SPECIAL SIGNAL HEADS
1&2
R
A
3
R
A
G
6 AVE. N., GRAND AVE., N. 32 ST.
PROPOSED SIGNALS
& CHANNELIZATION

FIG. 19



DIVISION ST. & LEWIS AVE. & 4th AVE. N. – WIDENING AND SIGNAL REVISION

FIG. 20

(23) Although traffic volumes at this intersection are relatively light on the side street (32nd) which would indicate the possible use of semi-actuated equipment, the critical intersections are to the east on 1st Avenue and the added capacity will be of little advantage. The fixed time controller gives the advantage of speed controls plus less pedestrian confusion which is always associated with pedestrian actuated equipment.

(37) In addition to the planned five-lane section on 1st Avenue South, the N-S geometrics should be improved to eliminate the offset caused by the newly installed median on 27th Avenue South of 1st Avenue S. This offset is not good from either a capacity or safety standpoint, as vehicles are required to shift alignment within the intersection with no curb or striping to guide them.

(38) System evaluation shows a large growth of traffic on Rimrock Road. The alignment of this intersection should be improved to eliminate the jog. In the interim, a red flasher should be included to stop north-south traffic.

(39) The close proximity of the three intersections in this complex under existing conditions subjects motorists to many conflicts and requires long clearance periods. The existing operation is approaching the level of Service "D" during p.m. conditions, Figure 21. Future predicted growth will require intersectional widening. Signal modernization should be compatible with this widening. The channelization shown in Figure 22 was designed to eliminate the crossing of traffic at flat angles and eliminates the need for long amber or all red intervals to clear two intersections. Improvement of the intersection will require additional right-of-way acquisition on the S.W., the property called Shadow Lane, and widening on the north.

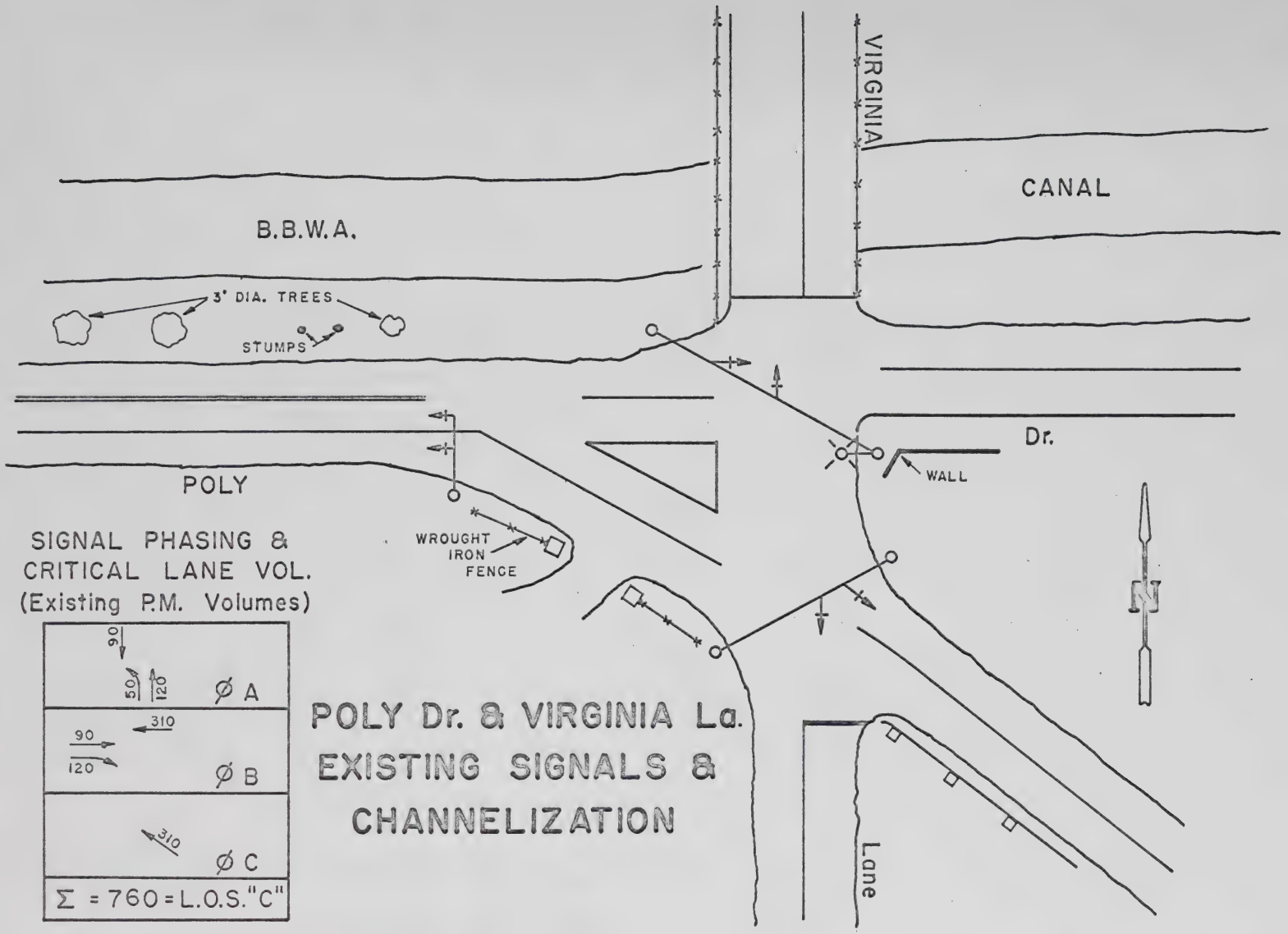

VIRGINIA
CANAL
B.B.W.A.
3' DIA. TREES
STUMPS
POLY
Dr.
WALL
WROUGHT IRON FENCE
SIGNAL PHASING & CRITICAL LANE VOL. (Existing P.M. Volumes)
90
50
120
Ø A
310
90
120
Ø B
310
Ø C
Σ = 760 = L.O.S. "C"
POLY Dr. & VIRGINIA La.
EXISTING SIGNALS & CHANNELIZATION
Lane
N

FIG. 21

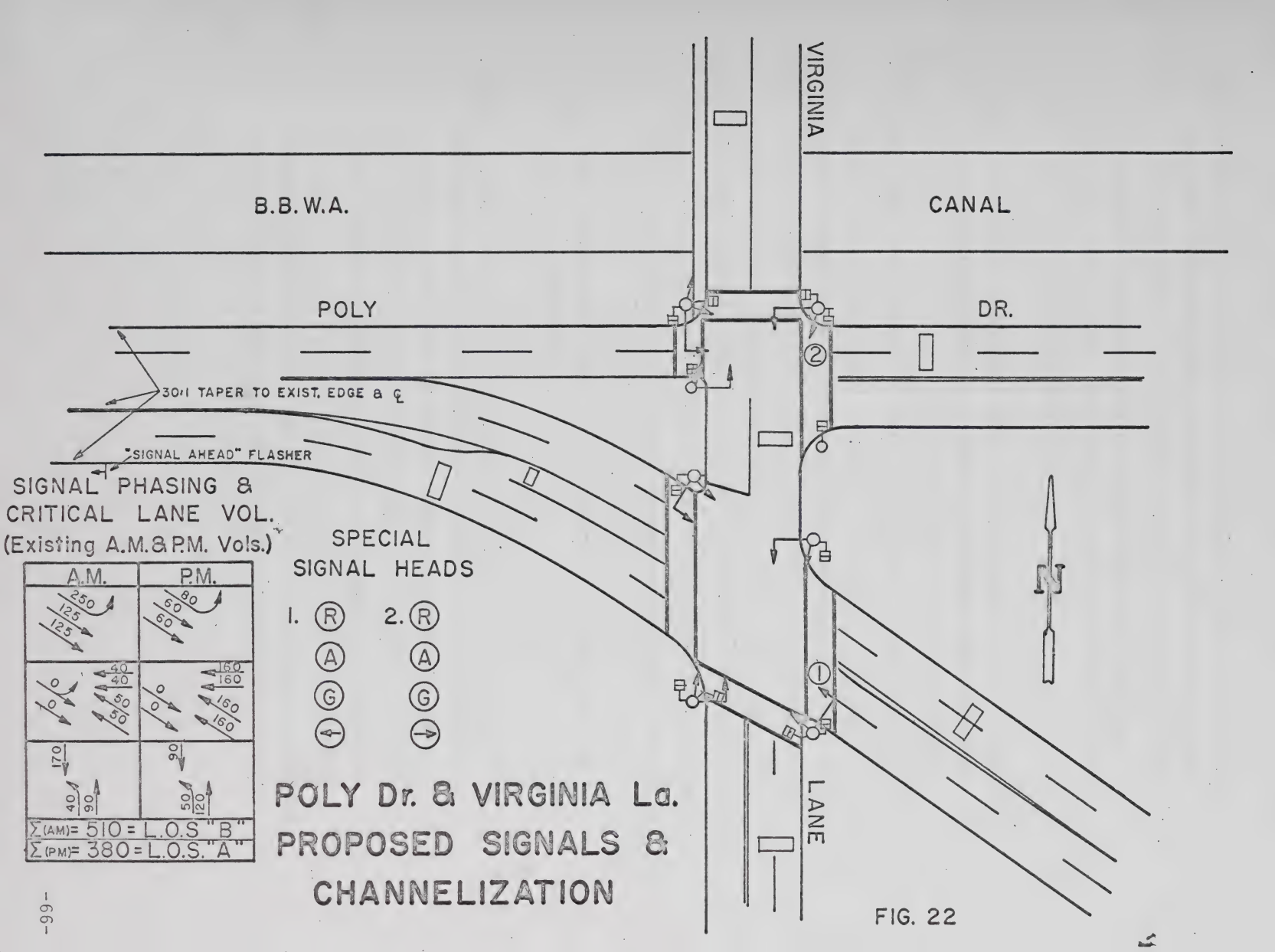

VIRGINIA
B.B.W.A.
CANAL
POLY
DR.
30:1 TAPER TO EXIST. EDGE & ℄
"SIGNAL AHEAD" FLASHER
SIGNAL PHASING &
CRITICAL LANE VOL.
(Existing A.M.& P.M. Vols.)
A.M.
P.M.
250
125
125
80
60
60
40
40
50
50
0
0
160
160
160
160
170
40
90
90
50
120
Σ(AM)= 510 = L.O.S "B"
Σ(PM)= 380 = L.O.S. "A"
SPECIAL
SIGNAL HEADS
1. R A G
2. R A G
POLY Dr. & VIRGINIA La.
PROPOSED SIGNALS &
CHANNELIZATION
LANE
N
1
2

FIG. 22

(40) The north-south alignment is not symmetrical. Improvements should be made to eliminate potential head-on and side-swipe accidents. Due to the future growth in traffic which can be expected on Grand Avenue and additional traffic generation of the West Park Plaza Shopping Center, a five-lane design should be anticipated on both 17th Street North and Grand Avenue.

(41) The signal at 16th Street North, the main entrance to the West Park Plaza Shopping Center, is not used to good advantage. Vehicles existing from the plaza must use driveways in close proximity to the signal and are often blocked by vehicles on Grand Avenue which are stopping for the signal. Figure 23. The Park Plaza sign is poorly located and the signal is of little assistance to orderly traffic flow from the Plaza parking area. Figure 24 demonstrates a solution to the problem. Driveways onto Grand Avenue in close proximity to the signal should be closed and curbing installed on the north approach to the signal to allow sufficient storage for efficient flow to an from the signal and preclude parking and unparking conflicts. The commercial nature of Grand Avenue would indicate the advisability of a fifth medial turning lane for two-way left turn refuge except at signalized intersections.

(42) The north-south jog at this intersection limits capacity and places the southbound curb lane traffic facing head on into the northbound curb lane traffic. This is not only potentially hazardous but can be confusing to motorists and produces a large conflict zone. Currently there are no buildings restricting realignment of this intersection. As property develops and increases in value, it may be extremely difficult and undoubtedly costly to improve such conditions. The jog should be eliminated prior to increased development. Figure 25.

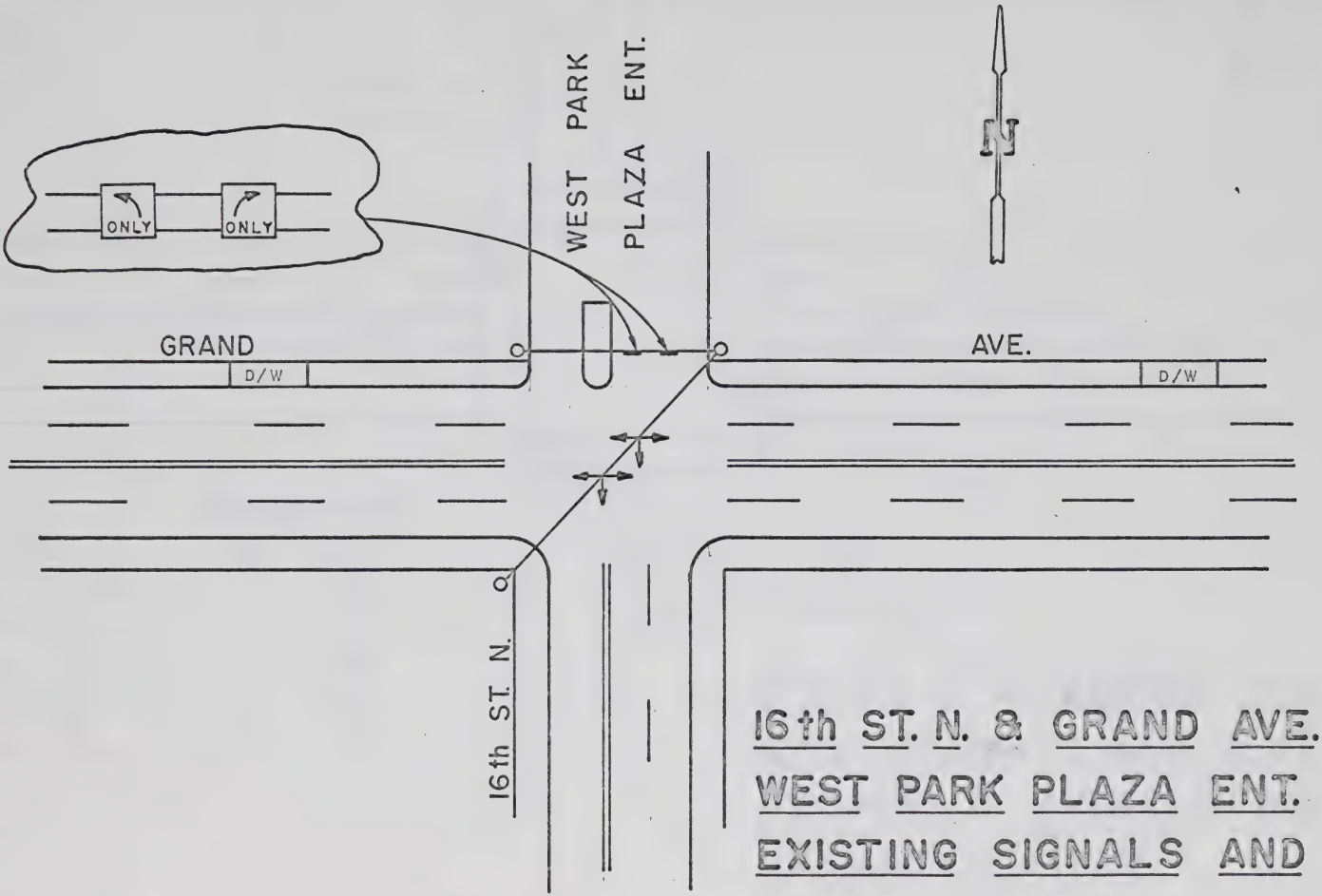

WEST PARK PLAZA ENT.
ONLY
ONLY
GRAND
D/W
AVE.
D/W
16th ST. N.
16th ST. N. & GRAND AVE.
WEST PARK PLAZA ENT.
EXISTING SIGNALS AND
CHANNELIZATION

FIG. 23

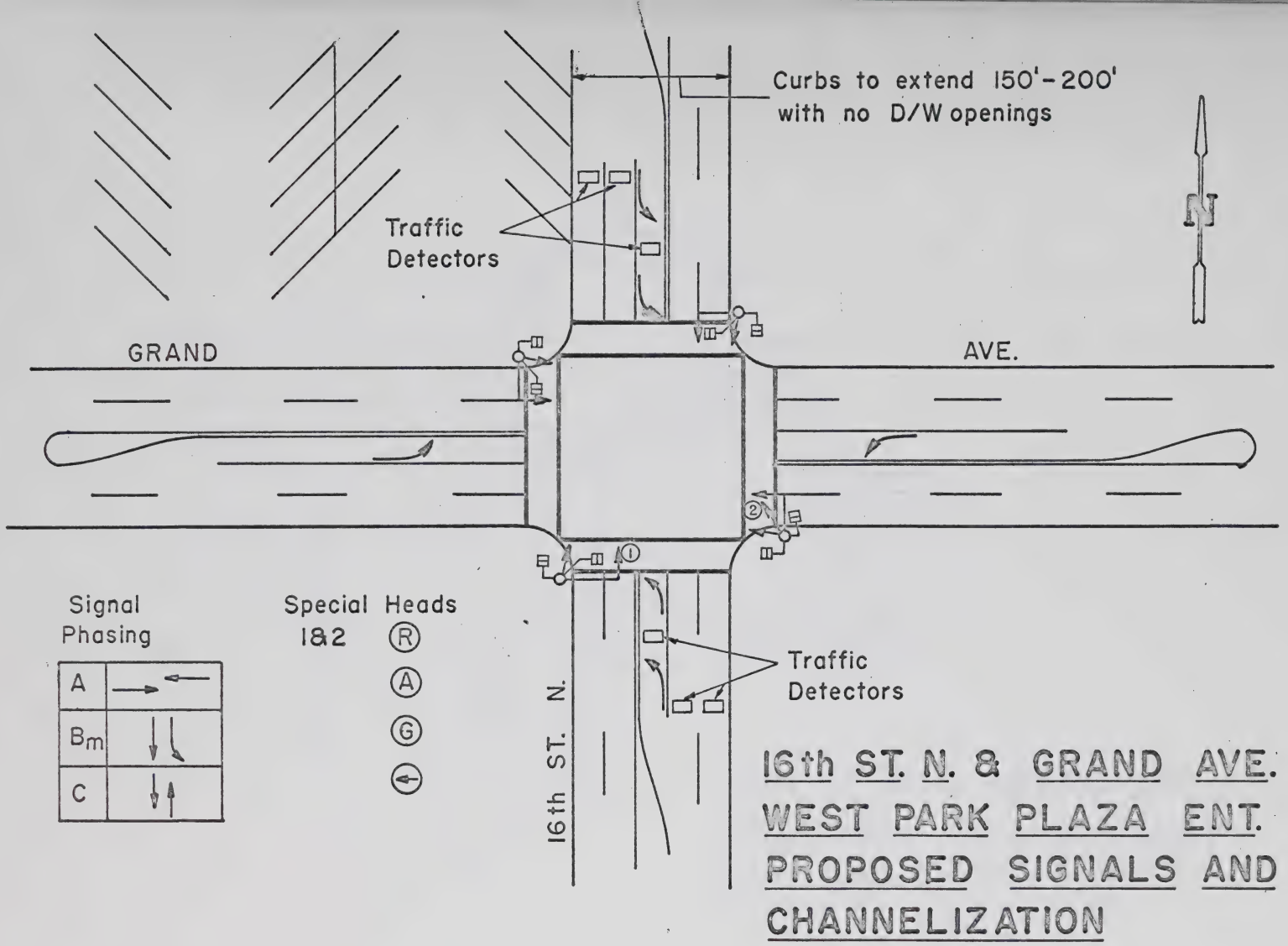
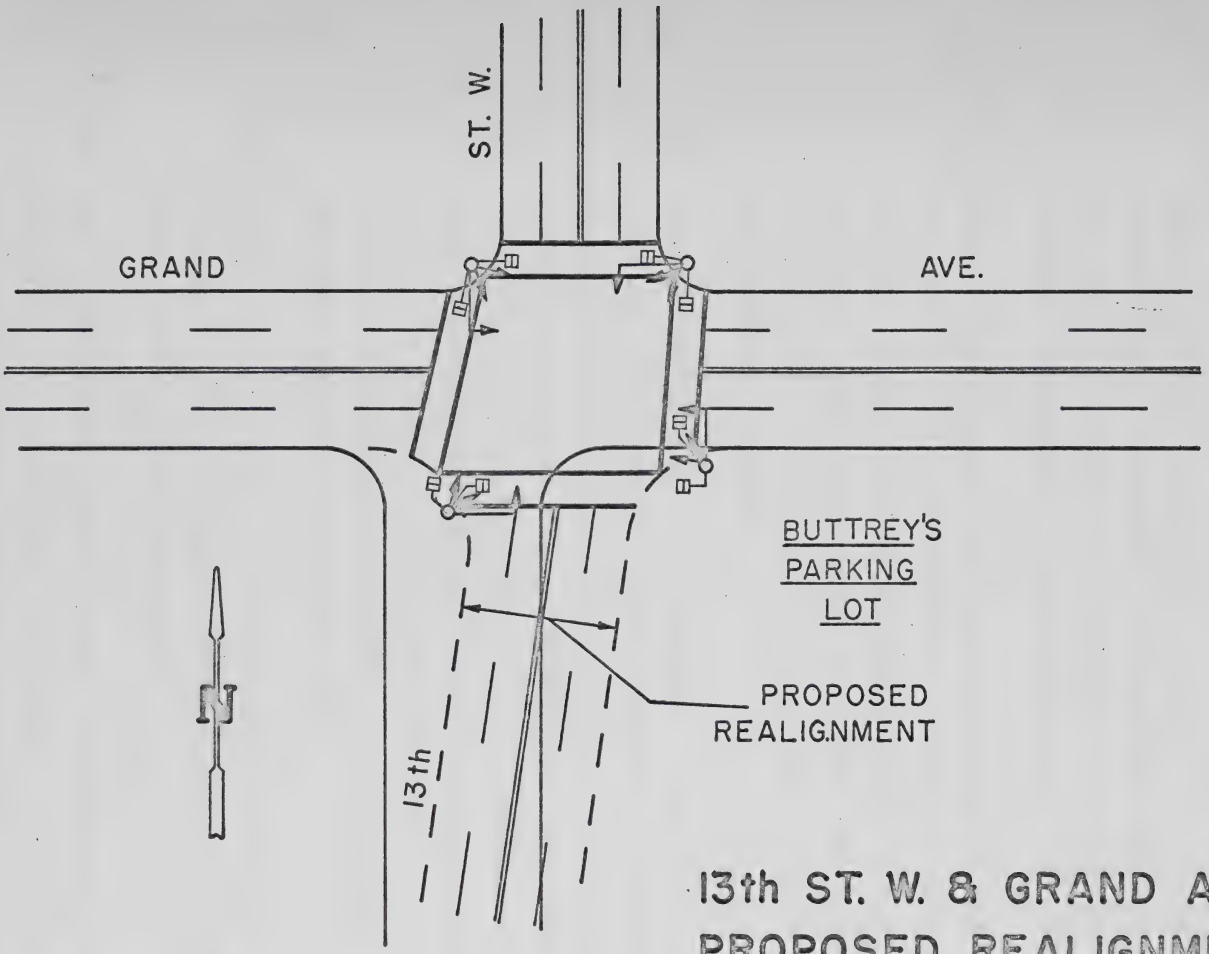

Curbs to extend 150'-200' with no D/W openings
Traffic Detectors
N
GRAND
AVE.
16th ST. N.
Traffic Detectors
Signal Phasing
A
Bm
C
Special Heads
1&2
R
A
G
16th ST. N. & GRAND AVE.
WEST PARK PLAZA ENT.
PROPOSED SIGNALS AND CHANNELIZATION

FIG. 24



13th ST. W. & GRAND AVE.
PROPOSED REALIGNMENT
AND SIGNALIZATION

FIG. 25

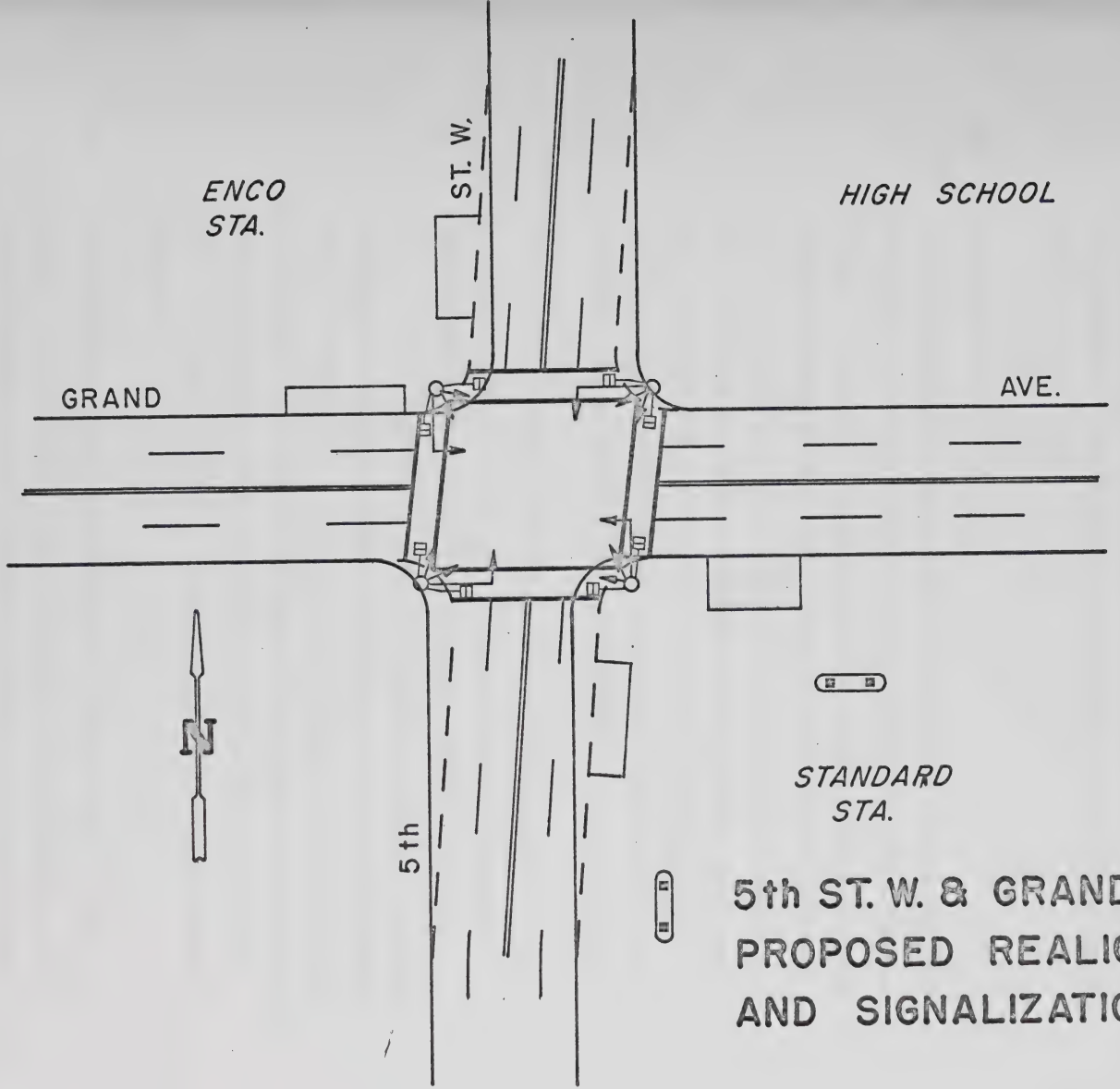
(43) Widening on the south leg of this intersection has improved the alignment, however, the painted center lines north and south are offset. The north leg centerline should be shifted about five feet east to align with the south leg centerline. The skew on Grand Avenue produces no problems. This controller should be converted to a semi-actuated controller due to its 1/8 mile spacing. A dual maximum controller with a 3 offset synchrolizer should be used.

(44) The offset north-south at this intersection again places the motorists in a "head-on" situation limiting capacity and safety. Realignment on the approaches to the intersection will require some R/W but will have no appreciable adverse affect on the service stations which are affected. Pedestrian signal indications should also be added. Figure 26.

(45) Alignment on 24th is all right, however, if Lewis is not to be limited in its future traffic carrying capabilities, the property on the northeast corner, which belongs to the West Side Baptist Church (current building site), should be acquired. If this is not possible at this time, the church should be requested to set back with the understanding that the City will purchase the property when funding is available. At the time this intersection was field checked, the beacon for Lewis was not flashing. As Lewis is required to stop, the flasher should be operating full time.

(46) During the field check, the centerline striping was nearly non-existent and should be repainted. Parking should be prohibited within 100 feet $\pm$ of the intersection.

(47) The single lane and right turn lane for westbound traffic could be converted to two lanes thru. The intersection should be striped for two approach lanes on all legs. Parking would be removed on 16th Street on the approaches to the intersection.



5th ST. W. & GRAND AVE.
PROPOSED REALIGNMENT
AND SIGNALIZATION

FIG. 26

(48) The north-south centerlines are offset. The centerline on the south leg should be shifted to line up with that on the north leg. If signal modernization takes place prior to widening, the pole on the northwest corner should be set back to accommodate future widening to four lanes.

(51) & (53) Sixth Street West Interchange:

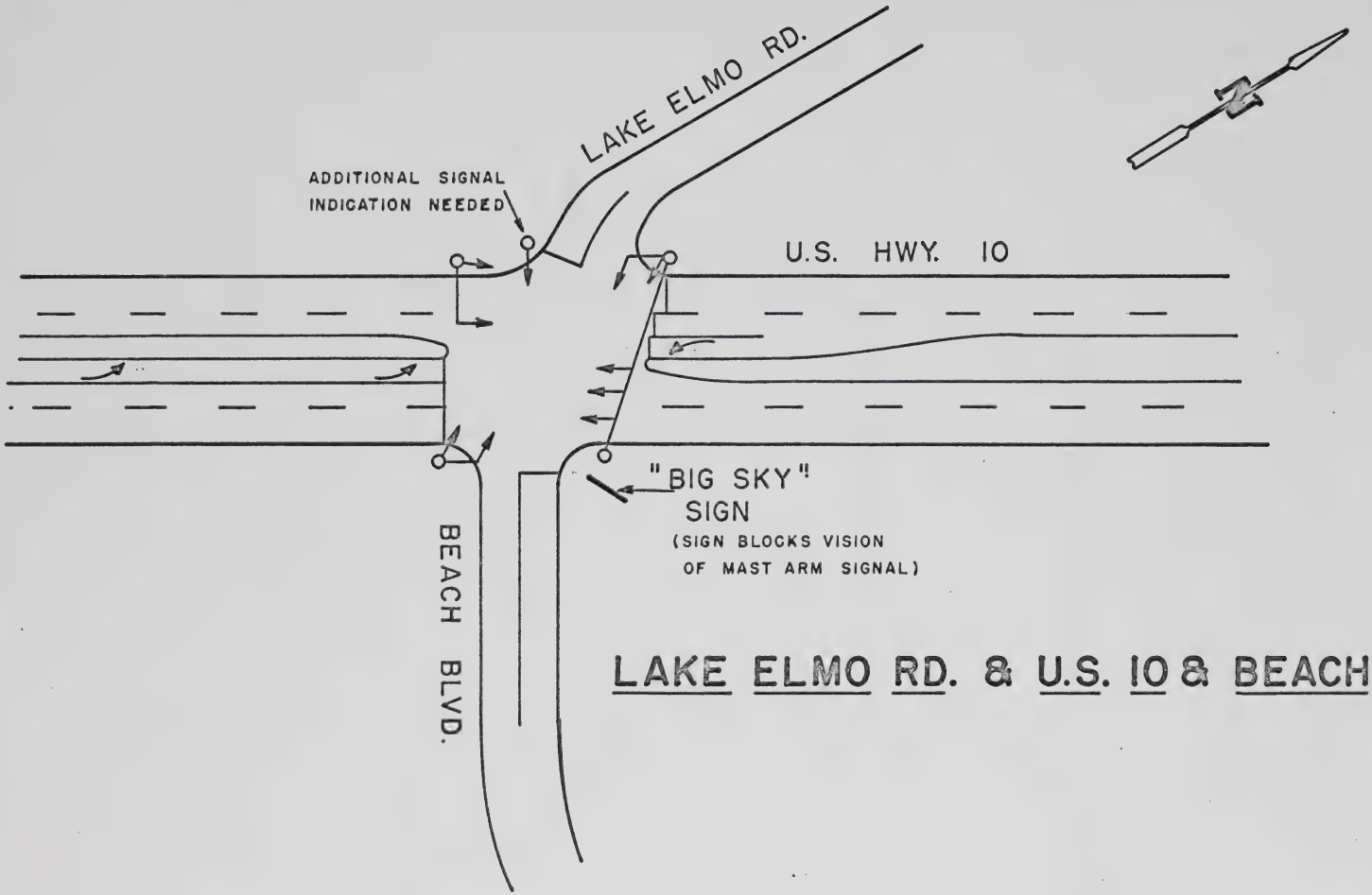
Projected traffic volumes in the Montana Avenue corridor are critical both at the Sixth Street West interchange and at the Division-Montana intersection. Improvement of the Sixth Street West interchange is needed both to accommodate the increased traffic from Central Avenue and to enable diversion to First Avenue South. Figure 14 shows an analysis of current and projected traffic volumes. The existing configuration would not operate well under the 1990 projected traffic volume. Figures 15 and 16 show a recommended design which could operate under this volume level.

It would be physically possible to provide left turn access to the eastbound on-ramp to U.S. 10 - Montana Avenue. This would probably work well under interim volume conditions, however, this would be questionable under 1990 peak hour traffic. It would be possible to install a vertical gate similar to that used on Interstate 5 reversible lanes in Seattle, Washington, which would permit this turn during peak traffic hours. There would be considerable merit in allowing a direct connection from Central to Montana to reduce the amount of traffic which is now forced thru the residential area.

(54) The centerline of the north leg lines up with the right curb line of the south leg. A transition should be made on the south leg cutting off the corner of the "Self Service Furniture" parking lot and the centerline of the north leg moved west.

(57) To meet the 1990 volume requirements, an express type facility will be needed on U. S. 10 (six lanes). The one-way grid system may have to be extended to provide the added capacity needed east-west. The Sixth Avenue North directional sign blocks the signal view for northbound traffic. It could be located to northwest of the intersection.

(59) The signals for Beach Boulevard are not well aligned and vision of the signals is blocked until about 150 to 200 feet from the intersection by the "Big Sky" sign. An additional post mounted signal on the southwest corner is needed. Figure 27.



LAKE ELMO RD. & U.S. 10 & BEACH BLVD

FIG. 27

FUTURE SIGNALS

In addition to the previously mentioned improvements, the following locations should be checked annually with systematic traffic counts to determine a priority of need and to see if signal warrants are met as traffic volume projections indicate growth in traffic demand at these locations:

Rimrock Road at 17th Street W.
Rimrock Road at Wisconsin St. (Speed control & progression)
Rimrock Road at Virginia Lane
Rimrock Road at N. 27th Street
Poly Drive at 17th Street W.
Poly Drive at 13th Street W.
Poly Drive at Wisconsin St. (Speed control & progression)
Poly Drive at N. 30th Street
Poly Drive at N. 27th Street
Colton Blvd. at 17th St. W.
Parkhill Drive at 17th St. W.
Parkhill Drive at 13th St. W.
Parkhill Drive at Virginia Lane
Grand Avenue at 24th St. W.
Lewis Ave. at 16th Street W.
Broadwater at 24th Street W.
Central Avenue at 24th St. W.
Central Avenue at 16th St. W.
Central Avenue at Moore Lane
Central Avenue at 8th Street W.
State Avenue at Orchard
State Avenue at 1st Avenue S.
U. S. 10 at Moore Lane
U. S. 10 at 4th Avenue N.

CONCLUSIONS & RECOMMENDATIONS

1. 38 of the 59 signalized intersections fail to meet national standards.
2. 136 additional signal faces are required. This is an increase of 45 percent over the present number of 303.
3. Pedestrian indications should be installed at all traffic actuated signals.
4. There are eight intersections requiring a total of 64 additional pedestrian signal indications, a 46 percent increase over the present number of 138.
5. Due to the magnitude of deficiences, a standardization of signal design should be adopted.
6. The mast arm type of signal mounting is recommended as a standard installation.
7. The maintenance of signal equipment in the field has been excellent. The currently initiated maintenance record system should be continued. A card file of signal timing should be initiated and maintained.
8. The existing "double alternate" traffic signal system in the Central Business District is the best system for two-way streets.
9. The one-way street and signal system is undeniably the safest and most efficient use of Central Business District streets in moving traffic and the system most often adopted to avoid congestion and at the same time, retain on-street parking.
10. A one-way street system in the CBD compatible with the 1990 proposed system is recommended.
11. The current two-way street system cannot accommodate future traffic volumes in the CBD. Reversible lanes are not practical due to the nearly balanced traffic split. The current building line precludes further widening to accommodate the projected volumes on a two-way street.
12. A 3 Dial - 3 Offset fixed time expansible system is recommended for control of the Central Business District signals. All three dials need not be purchased initially.

13. Leased telephone lines appear to be the most economical type of interconnect and should be further pursued as a standard type of interconnect.

14. Signals in the "West Central" system should have expansible fixed time controllers with the exception of those signals located on one-eighth mile spacing which should be actuated. A 50 second cycle should be used and left on the "off peak" setting until directional volume and over capacity dictate a need for directional progression.

15. The"Sixth Street West" system should be revised both geometrically and in signal system type to accommodate future traffic volumes.

16. Little benefit can be gained at many of the existing signalized intersections without first improving the geometrics for increased capacity and safety.

17. The City should be prepared to participate in the TOPICS program to assist in financing needed traffic improvements.

18. Systematic review of potential signal locations should be initiated.

APPENDIX A

INTERSECTION CODE NUMBERS

Code Number	Intersection
1.	9th Avenue North and N. 27th Street
2.	6th Avenue North and N. 27th Street
3.	6th Avenue North, Grand Avenue and N. 32nd Street
4.	6th Avenue North and N. 29th Street
5.	6th Avenue North and N. 28th Street
6.	"C" Avenue and N. 32nd Street
7.	6th Avenue North and N. 19th Street
8.	Division Street, Lewis Avenue and 4th Avenue N.
9.	4th Avenue North and N. 32nd Street
10.	4th Avenue North and N. 30th Street
11.	4th Avenue North and N. 29th Street
12.	4th Avenue North and N. 28th Street
13.	4th Avenue North and N. 27th Street
14.	3rd Avenue North and N. 30th Street
15.	3rd Avenue North and N. 29th Street
16.	3rd Avenue North and N. 28th Street
17.	3rd Avenue North and N. 27th Street
18.	2nd Avenue North and N. 30th Street
19.	2nd Avenue North and N. 29th Street
20.	2nd Avenue North and N. 28th Street
21.	2nd Avenue North and N. 27th Street
22.	1st Avenue North and Division Street
23.	1st Avenue North and N. 32nd Street
24.	1st Avenue North and N. 30th Street
25.	1st Avenue North and N. 29th Street
26.	1st Avenue North and N. 28th Street
27.	1st Avenue North and N. 27th Street
28.	1st Avenue North and N. 26th Street
29.	1st Avenue North and N. 25th Street
30.	1st Avenue North and N. 13th Street

Code Number	Intersection
31.	Montana Avenue and Division Street
32.	Montana Avenue and N. 29th Street
33.	Montana Avenue and N. 28th Street
34.	Montana Avenue and N. 27th Street
35.	1st Avenue South and S. 29th Street
36.	1st Avenue South and S. 28th Street
37.	1st Avenue South and S. 27th Street
38.	Rimrock Road and 13th Street W.
39.	Poly Drive & Virginia Lane
40.	Grand Avenue and 17th Street W.
41.	Grand Avenue & 16th Street W.
42.	Grand Avenue & 13th Street W.
43.	Grand Avenue & 8th Street W.
44.	Grand Avenue & 5th Street W.
45.	Lewis Avenue & 24th Street W.
46.	Lewis Avenue & 5th Street W.
47.	Broadwater Avenue & 16th Street W.
48.	Broadwater Avenue & 8th Street W.
49.	Broadwater Avenue & 5th Street W.
50.	Broadwater Avenue & Division Street
51.	Central Avenue & 6th Street W.
52.	Deleted
53.	Minnesota Avenue & 6th Street W.
54.	Grand Avenue & 15th Street W.
55.	6th Avenue N. & N. 30th Street
56.	1st Avenue North (U.S. 10,12) and U. S. 87 East
57.	U.S. Highway 10,12 (Main Street) and 6th Avenue N.
58.	U.S. Highway 10,12 (Main Street) and Montana Highway 318
59.	U.S. Highway 10,12 (Main St.) and Lake Elmo Road
60.	U.S. Highway 10,12 (Main St.) and Milton Lane

APPENDIX B

ALPHABETICAL LIST OF INTERSECTIONS

Intersection	Code Number
1st Avenue North and North 13th Street	30.
1st Avenue North and North 25th Street	29.
1st Avenue North and North 26th Street	28.
1st Avenue North and North 27th Street	27.
1st Avenue North and North 28th Street	26.
1st Avenue North and North 29th Street	25.
1st Avenue North and North 30th Street	24.
1st Avenue North and North 32nd Street	23.
1st Avenue North & Division Street	22.
1st Avenue North (U.S. 10,12) and U.S. 87 East	56.
1st Avenue South and South 27th Street	37.
1st Avenue South and South 28th Street	36.
1st Avenue South and South 29th Street	35.
2nd Avenue North and North 27th Street	21.
2nd Avenue North and North 28th Street	20.
2nd Avenue North and North 29th Street	19.
2nd Avenue North and North 30th Street	18.
3rd Avenue North and North 27th Street	17.
3rd Avenue North and North 28th Street	16.
3rd Avenue North and North 29th Street	15.
3rd Avenue North and North 30th Street	14.
4th Avenue North and North 27th Street	13.
4th Avenue North and North 28th Street	12.
4th Avenue North and North 29th Street	11.
4th Avenue North and North 30th Street	10.
4th Avenue North and North 32nd Street	9.
6th Avenue North and North 19th Street	7.
6th Avenue North and North 27th Street	2.
6th Avenue North and North 28th Street	5.
6th Avenue North and North 29th Street	4.

Intersection	Code Number
6th Avenue North and North 30th Street	55.
6th Avenue North, Grand Avenue and North 32nd Street	3.
9th Avenue North and North 27th Street	1.
Broadwater Avenue and Division Street	50.
Broadwater Avenue and 5th Street W.	49.
Broadwater Avenue and 8th Street W.	48.
Broadwater Avenue and 16th Street W.	47.
"C" Avenue and North 32nd Street	6.
Central Avenue and 6th Street W.	51.
Division Street, Lewis Avenue and 4th Avenue N.	8.
Grand Avenue and 5th Street W.	44.
Grand Avenue and 8th Street W.	43.
Grand Avenue and 13th Street W.	42.
Grand Avenue and 15th Street W.	54.
Grand Avenue and 16th Street W.	41.
Grand Avenue and 17th Street W.	40.
Lewis Avenue and 5th Street W.	46.
Lewis Avenue and 24th Street W.	45.
Minnesota Avenue and 6th Street W.	53.
Montana Avenue and North 27th Street	34.
Montana Avenue and North 28th Street	33.
Montana Avenue and North 29th Street	32.
Montana Avenue and Division Street	31.
Poly Drive and Virginia Lane	39.
Rimrock Road and 13th Street W.	38.
U.S. 10,12 (Main St.) and 6th Avenue N.	57.
U.S. 10,12 (Main St.) and Lake Elmo Road	59.
U.S. 10,12 (Main St.) and Milton Lane	60.
U.S. 10,12 (Main St.) and Montana Highway 318	58.
Deleted	52.

APPENDIX C

DRAFT COMMENTARY AND RESPONSE

1. Figure 2, p.20

   Commentary:

   (a) BPR recommends using triple indication on one-way streets rather than two indications as illustrated.

   (b) The use of 10' side mount height and of 7' top mount pedestrian signals at the same intersection is not consistent. State Highway Commission uses 7' all around.

   Response:

   (a) We concur that triple indications are desirable, however, the placement of the third indication is critical. In the CBD, post mounted signals give conflicting indications to the pedestrians. Louvering the post mounted vehicular indications is only a partial answer as the required focus to preclude pedestrian vision directs the signal to a very limited area for vehicular traffic. A third mast arm signal indication does not seem justified for a three lane approach, nor could the following criteria be met if three indications were placed in 36 feet of roadway:

   > "A distance of 20 to 30 feet between lines drawn perpendicular to the signal faces is desirable." [1]

   [1] Traffic Engineering Handbook; P.386

   (b) We agree with this comment about inconsistency of pedestrian signal height and have changed the Type 1 pole (top mount) to 10'. The justification for the 10' rather than the 7' typical is due to the requirement for "one-way" signing. The sign height is set at 7' clear to the bottom as per MUTCD. Raising the sign above the signal indications greatly reduces the reflectivity of such signing at night. The visability of signals at this height is not a problem for pedestrians or motorists and conforms with MUTCD. It is our recommendation that this 10' height be adopted in the CBD where one-way streets are probable.

2. Figure 5, p. 29

Commentary:

We suggest, that in order for the signals at the intersection of Division, Broadwater and First Avenue North to operate 2-phase, Broadwater should be one-way westbound and Custer Avenue one-way eastbound.

Response:

This intersection design is part of the Morrison-Maierle, Inc. contract. We concur that if a cross over between Broadwater and Custer can be made to facilitate this move, that it be done. The intersection alignment should be improved in either case. The intersection could operate as 3-phase until volumes increased. Drawings have been changed for one-way operation.

3. P. 30, par. 1

Commentary:

Why not got to 25th Street one-way northbound in the interim system. Explain why 27th and 28th couplet can not be adopted.

Response:

25th Street is used in lieu of 26th as this maintains the one-way grid system. It is not possible to progress traffic thru the system as well with 25th one-way northbound as with 26th one-way northbound. Expanding Table E to 25th Street illustrates this (see following page).

4. P. 39, par. 2

Commentary:

We believe the first sentence should contain the phrase "Cost of telephone interconnect."

Response:

So changed.

TABLE E

26TH STREET NORTHBOUND

	32nd Street	31st Street	30th Street	29th Street	28th Street	27th Street	26th Street	25th Street
6th Ave.N.			0	37.5	25.0	12.5	0	37.5
			X		X		X	
4th Ave.N.	25.0		0	12.5	25.0	37.5	0	12.0
3rd Ave.N.			37.5	25.0	12.5	0	37.5	25.0
2nd Ave.N.			25.0	37.5	0	12.5	25.0	37.5
1st Ave.N.	37.5		12.5	0	37.5	25.0	12.5	0
Montana			0	12.5	25.0	37.5	0	12.0
Minnesota								
1st Ave. S.				37.5	12.5	12.5		

The only breaks in progression "X" in the one-way 26th system are caused by the absence of 5th Avenue and 6th Avenue being westbound rather than eastbound.

25TH STREET NORTHBOUND

	32nd Street	31st Street	30th Street	29th Street	28th Street	27th Street	26th Street	25th Street
6th Ave.N.			0	37.5	25.0	12.5	0	37.5
			X		X		X	
4th Ave. N.	25.0		0	12.5	25.0	37.5	0	12.0
3rd Ave. N.			37.5	25.0	12.5	0	37.5	25.0
2nd Ave. N.			25.0	37.5	0	12.5	25.0	12.0
1st Ave. N.	37.5		12.5	0	37.5	25.0	12.0	0
Montana			0	12.5	25.0	37.5	0	12.0

With 25th northbound rather than southbound, three additional breaks in progression are added. The break between 1st and Montana actually facilitates movement from Montana to 25th.

5. Page 47

Commentary:

At top of page, 2nd and 3rd boxes under "Critical Phasing and Critical Lane Volumes" the traffic volumes are reversed for the movements within the box. Central and 6th Street West approach from east 170 vph in north lane must be through and right.

Response:

We concur.

6. Page 49, 6th Street West and Central Avenue

Commentary:

(a) We do not think the merge of the westbound and north to west traffic on the same phase is good.

(b) How does Central Avenue traffic from the east wanting to go south get through?

Response:

(a) The comment is well taken. Figure 16 is a schematic drawing. The merge of four lanes into two is not desirable if it occurs all at one point. Westbound Central Avenue traffic should be merged into a single lane prior to the merge with traffic from the south. The drawing has been modified to emphasize this. The volume in the merging lanes totals about 500 vehicles per hour which is not a problem volume. As a safety factor, the westbound Central Avenue traffic could be controlled by a yield or stop sign as even the projected 1990 volume (260±) with a random arrival factor of two could be stored between the 6th Street West intersection and the merge point.

(b) Arrows on Figure 16 attached show this movement.

7. Pages missing following Table G.

Response:

The pages following Table G relfect those additional comments noted under colume "K". None are missing.

8. Figure 17, ØB

Commentary:

Should show westbound from 6th Avenue North to Division Street traffic stopped during Ø.

Response:

We concur and have corrected same.

9. Figure 18

Commentary:

(a) Special signal head arrow indication 1 and 2 and 3 and 4 are transposed.

(b) There should be double indication including a mast arm for westbound on Grand and onto Division.

Response:

(a) We concur and have corrected same.

(b) We concur and have corrected same.

10. Figure 19

Commentary:

(a) Westbound on 6th Avenue should have double indication including mast arm for movement onto Grand and onto Division.

(b) Free right turn onto Division from Grand should be stopped during ØA, if the movement is appreciable.

Response:

(a) So changed.

(b) Concur - present volume 10 vehicles per hour.

11. Figure 22

Commentary:

(a) We question ØB merging of westbound Poly Drive traffic and westbound Grandview Blvd. traffic.

(b) Left turns on Poly Drive from east to south would be in direct conflict with Grandview Blvd. and Poly Drive traffic.

(c) We would recommend that there be a mast arm and side of pole mounting on the far right side of the first intersection of each approach.

Response:

(a) Merging the 320 vph from Grandview Boulevard into a single lane should not present a problem. If it does, the south lane of Poly Drive could be channeled into the north lane (total combined volume 320 vph) and Grandview traffic brought in as an add lane.

(b) Left turns from Poly westbound to southbound are in conflict with Grandview traffic, however, they are entering a separate intersection controlled by typical far side signal indications.

(c) We concur.

12. Page 78, (12)

Commentary:

A 2-dial system with 2 split and 3 offsets per dial will be installed on the F9999(10) project for the primary road system in the CBD.

Response:

We do not differ here. A note has been added.

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